

MEMORANDUM
Engineering Division

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Date: February 22, 2005
To: Distribution
From: Gail Seeds
Subject: Main Sewage Pump Station Evaluation, final report Jan. 2005

Kennedy/Jenks Consultants was retained to conduct an evaluation of the Main Sewage Pump Station, develop a hydraulic model of the station and its upstream interceptors, and recommend improvements. Attached is a copy of Kennedy/Jenks' final report for your records.

Gail

Attachment

cc: D. Cuciz, S. Smith, D. Wong, G. Armendariz/M. Rogge, S. Erickson, G. Seeds, File 6079.1
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MAIN PUMP STATION EVALUATION

FINAL

Jan. 2005

Prepared for

City of Milpitas

455 E. Calaveras Blvd.

Milpitas, CA 95035

K/J Project No. 985002.04

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SECTION 1: INTRODUCTION

1.1 Existing Contracts

On 8 January 1998, the City of Milpitas entered into a contract with Kennedy/Jenks Consultants for design and construction review services associated with the City of Milpitas Parallel Force Main Project. This project consists of the construction of a parallel force main from the City of Milpitas Main Pump Station (PS) to the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP). The construction of the new parallel force main has been completed and the force main placed in service.

On 7 December 1999, Amendment #1 to the original contract was executed. The purpose of Amendment #1 was to conduct an evaluation of the Main PS, and to develop a hydraulic model of the Main PS and its upstream interceptors.

1.2 Scope of Amendment #1

Amendment #1 was divided into 4 tasks. They are:

- Task 1: Documentation of the existing system
- Task 2: Development of a hydraulic model for the Main PS
- Task 3: Prepare recommendations for improvements to the Main PS
- Task 4: Review of Main PS controls and control strategy.

The purpose of Task 1 is to compile design and operational information on the existing Main PS, the existing interceptors discharging into the pump station, and on the existing new and parallel force mains that discharge from the Main PS.

The purpose of Task 2 is to model the Main PS system as a whole. The system to be modeled includes the critical interceptor system, the new grinder structure, and the upstream interceptors. One goal of this model is to determine how the interceptors perform under backwater conditions created by the operation of the Main PS.

The purpose of Task 3 is to investigate ways to expand the capacity of the Main PS from a base dry weather flow of 9-12 MGD to a peak wet weather flow of 40 MGD; and to enhance the current operation of the Main PS. Consideration also is given to the operation of the Main PS during current nighttime low-flows of 5 MGD.

The purpose of Task 4 is to evaluate the current operating strategy and to develop a control strategy that integrates wetwell surface elevation, flow, and pump operation with the operation of the modulating butterfly valves installed on the new force main and added to the existing force main.

SECTION 2: BACKGROUND

2.1 Main Pump Station

The Main PS originally served as the pumping station into the Milpitas Wastewater Treatment Plant (WWTP), and was constructed in 1965. The Milpitas WWTP was abandoned in 1972, and the WWTP pumping facilities were converted into a pumping station that pumps all wastewater generated from Milpitas to the SJ/SC WPCP.

The Main PS is generally described as a 31-foot diameter concrete outer cylinder with a 10-foot diameter inner cylinder. The inner cylinder serves as the wetwell for the pumps that are located radially around the wetwell. Currently there are 4-250 hp pumps installed in Main PS. At one time there were up to five pumps of varying horsepower installed in the Main PS.

2.1.1 Design Criteria

In August 1986 a report was prepared by John Carollo Engineers that outlined recommended improvements to the Main PS. This report recommended that the Main PS be upgraded in the following two phases:

- Phase I – Remove 1-100 hp pump and install 3-250 hp pumps, and replace the existing bar screen structure
- Phase II – Remove the two remaining 100 hp pumps and add a fourth 250 hp pump, and construct the parallel force main from Milpitas to San Jose.

In recommending the Phase I upgrades, the report states; "The three 250 hp pumps would increase the pump station capacity from the present 16 MGD to 27 MGD with one 250 hp pump considered a standby. **The two remaining 100 hp pumps would operate during periods of low flow to reduce cycling of the pumps.**" (emphasis added).

The report further stated that the Phase II project should proceed if efforts to correct the City's inflow/infiltration (I/I) problem were not corrected. Upon completion of Phase II the maximum pumping capacity of the Main PS would increase to 48 MGD. However, no mention is made as to how low flows will be accommodated once the smaller 100 hp pumps are removed.

2.1.2 1997 Main PS Improvements Project

The last major improvements made to the Main PS were constructed in 1997-99. These improvements incorporated the recommendations of the 1986 Carollo report, and generally consists of the following:

- Construction of a new grinder screen and by-pass structure
- Construction of a new electrical building, including a new standby generator

- Replacement of the last remaining 100-hp pump with a new 250-hp pump (The new pump is #1 and the remaining 250-hp pumps are #3, 4, and 5. There is no pump #2.)
- Upgrading the electrical controls at the Main PS.

2.2 Force Mains

The original force main was constructed in 1972 and consists of a 36-inch diameter welded steel (WS) line. A new parallel force main was constructed in 2001/02 and consists of a 36-inch high-density polyethylene (HDPE) from the Main PS west to Zanker Road, and a 36-inch ductile (DI) line from Zanker Road west to the Milpitas Headworks. The system pumping curves for these two lines are approximately equal. The reason for this is that while the HDPE line has a higher "C" value than the WS line, it has a smaller inside diameter.

2.3 Interceptors

Figure 1 is a schematic that shows the relationship among the Main PS, the new grinder structure, the parallel force mains, and the 4 interceptors feeding into the Main PS. Three of these Interceptors (Sunny Hills, California, and Marylinn) bring flow from the west across I-880. The fourth interceptor brings flow from the south across Highway 237, and from the McCarthy Ranch development.

It is to be noted that three of these interceptors merge at the McCarthy Blvd. Junction Structure.

2.4 Design and Current Flows

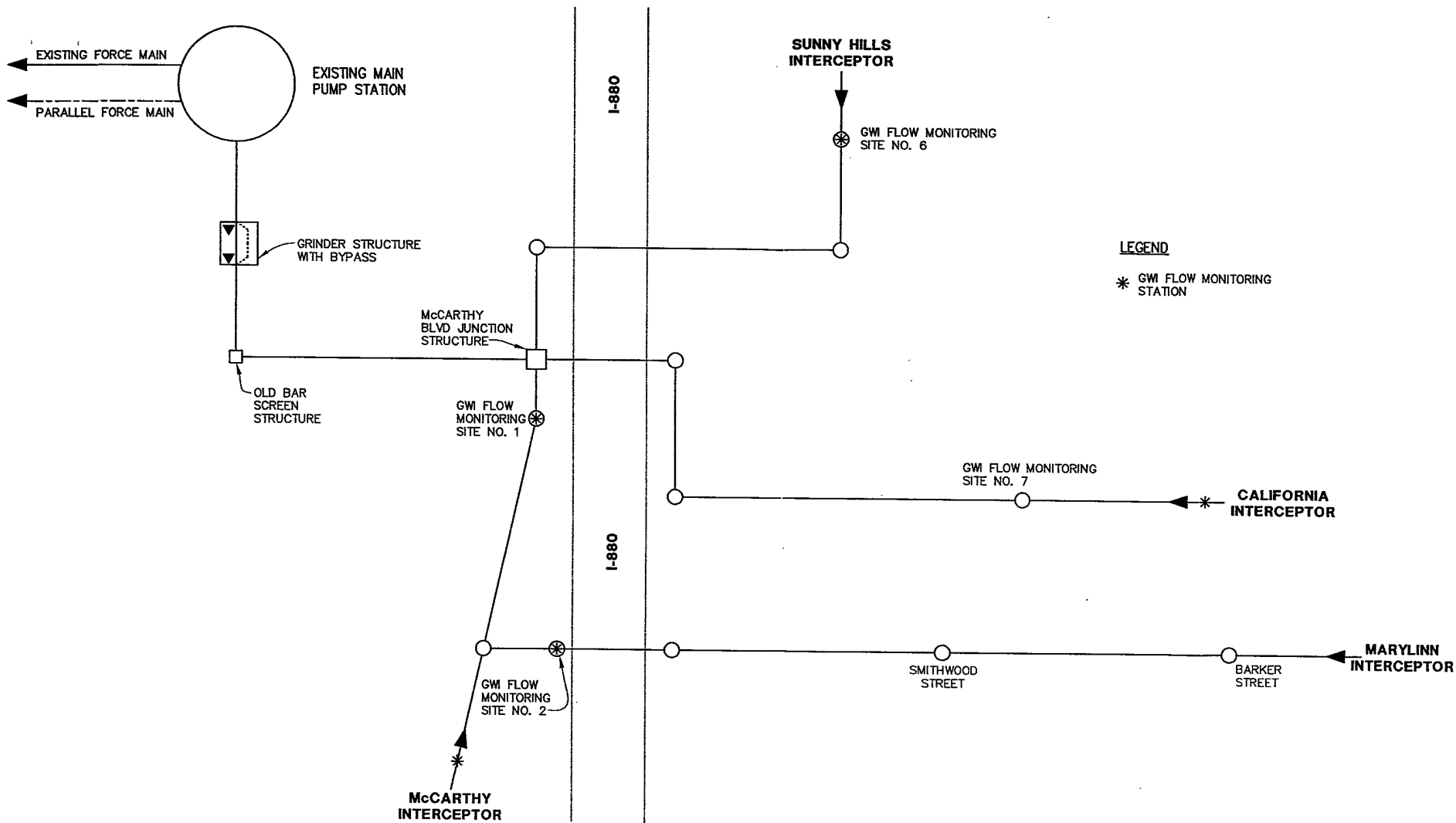
The operation of these facilities and the phasing of future improvements is determined by anticipated flows, and how current flows match the anticipated flows.

The 1986 Carollo Report that contained an evaluation of the Main PS stated that since 1982 (the report was prepared in 1986), the annual average flow has varied from 4.96 to 6.07 MGD. The Main PS report also referenced the November 1984 Master Plan that projected the average daily flow to increase to 13.98 in 1990 and 18.35 by 2000.

In the 1994 Sewer Master Plan Update that was prepared by John Carollo Engineers, current and future flows are summarized in Table 1.

TABLE 1: 1994 WASTEWATER FLOW PROJECTIONS

WASTEWATER FLOW	1994	2010
Average Dry Weather (ADWF)	8.4 MGD	11.6 MGD
Peak Dry Weather (PDWF)	9.8	13.6
Peak Wet Weather (PWWF)	26.6	35.0



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* GW FLOW MONITORING STATION

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MAIN PUMP STATION SYSTEM SCHEMATIC
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FIGURE NO.

The ADWF and PDWF values shown in Table 1 are representative of current operation during dry periods. Circular charts from the venturi meter that measures the pump discharge are included in Appendix A. These charts show that the peak dry weather flow in August and September 2000 varied from 9-12 MGD. These charts also show the minimum nighttime flow during the dry period is approximately 5 MGD. These flows are also representative of flows observed in the summer of 2003.

2.5 Existing Pumps

There are four 250 hp pumps currently installed in the wetwell. Three of them (Worthington Pumps #3, 4 and 5) were installed in 1987, and one (Ingersoll-Dresser #1) was installed in the 1998. The pump curves for both types of pumps are included in the Appendix A. The pump curves indicate that these pumps are very similar, and that both produce approximately 9400 gpm at 88 feet of head. The Worthington pumps are operating close to their maximum efficiency at 9400 gpm, while the Ingersoll-Dresser pumps achieve their maximum efficiency at approximately 11,200 gpm. These operating points are based on the pumps operating at 100% speed (890 rpm).

Upon review of the operating characteristics of these pumps in the Main PS, Carollo Engineers recommended that the pumps be limited to 90% of the maximum speed to insure that the Net Positive Suction Head (NPSH) requirements of the pumps are met. (See memo dated 4 May 2000 contained in Appendix B). Currently all four pumps are operated in accordance with this memo.

2.5.1 System Curves

The Carollo memo also contains the system curves for the 36-inch welded steel force main (it is to be noted that the new HDPE/DI force main has a similar system curve due to the smaller inside diameter of the HDPE line). This system curve indicates that the maximum pumping capacity of the 250 hp pumps is approximately 16 MGD at 40 feet of head at 90% speed. This is for one pump operating. For two pumps operating the maximum flow increases to approximately 24 MGD, and for three pumps operating the maximum output is approximately 26.5 MGD.

These operating points are all based on the use of a single force main. For both force mains in operation, and all four pumps operating, the maximum discharge would be approximately 48 MGD. However, all four pumps should not be operated out of the existing single wetwell on a long-term basis.

The other important observation that can be made from these system curves pertains to low flow operation. The minimum nighttime flow is approximately 5 MGD and lasts for approximately 2-3 hours daily (3:00 a.m. to 6:00 a.m.). The system curve for a single pump indicates that the discharge head required at 5 MGD is only 20 feet. For the 250 hp pumps to discharge at a rate of 5 MGD and 20 feet of head, their speed must be reduced to approximately 50% of the maximum. It is to be noted that the pumps will automatically shut off if their speed drops below 50%. Based on the available records and discussions with operational staff, it does not appear that the pumps shut off during periods of low flow. Therefore, they are operating slightly above 50% during low-flow periods. This is a low speed for regular operation.

The pumps must operate at this point for 3 hours every day unless there is a significant rainfall event.

2.6 Operation of Main PS

2.6.1 Design Operating Points

The August 1986 Sewer Pump Station Expansion Report prepared by Carollo Engineers identified the existing Main PS elevations and pump operating points as shown in Table 2.

TABLE 2: ORIGINAL PUMP OPERATIONAL POINTS

ELEVATION	DESCRIPTION
-16.50	Wet Well invert
-11.50	Invert 54-inch Influent Sewer
-6.80	Crown 54-inch Influent Sewer
-12.17	Low Level Alarm
-11.75	Stop Lead 100 HP Pump
-10.50	Stop Both 250 HP Pumps & Start Lead 100 hp Pump
-8.40	Start Lag 100 HP pump
-7.60	Stop both 100 HP Pumps and Start Both 250 HP Pumps
-5.50	High Water Alarm

2.6.2 Current Operating Points

After completion of the 1997 rehabilitation project and after running the pump station for a break-in period, the City of Milpitas set the new operating points as shown in Table 3.

TABLE 3: CURRENT MAIN PS OPERATING POINTS

BUBBLER READING	WATER DEPTH	WATER SURFACE ELEVATION	DESCRIPTION
11.5	12.5	-4.0	High Water Alarm
4.0	5.0	-11.5	Low Water Alarm
5.0	6.0	-10.5	Start Lead Pump
4.5	5.5	-11.0	Stop Lead Pump
5.0	6.0	-10.5	Minimum Sped, Lead Pump
7.5	8.5	-8.0	Maximum Speed, Lead Pump
8.5	9.5	-7.0	Start Lag Pump
6.5	7.5	-9.0	Stop Lag Pump
11.0	12.0	-4.5	Start Standby Pump
8.0	9.0	-7.5	Stop Standby Pump

The principal difference in these two operational plans is that originally, the elevation of the wetwell was kept below the invert of the 54-inch influent sewer and now the operational wetwell elevation (-10.5 to -8.0) is between 1-foot and 3.5-feet above the invert of the 54-inch influent sewer. The higher operating level was selected in order to increase submergence over the pumps thereby reducing the potential for the formation of vortices. However, the elevation cannot be raised too high or the grinder structure will be flooded. The lower floor elevation of the new grinder structure is -2.50. A wetwell elevation in the pump station greater than this will flood the grinder structure.

SECTION 3: ANALYSIS OF MAIN PUMP STATION

3.1 Wet Well Design

3.1.1 Design Guides

Design guides, such as those published by the Hydraulic Institute, exist that present basic criteria for the design of pump station wetwells. In addition, there are generally accepted engineering practices that can be used for wetwell design.

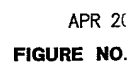
One fundamental criterion is that the flow to the pump inlet should be even and not contain significant turbulence. This minimizes the potential for the vortex formation. Uneven flow and the formation of vortices can lead to reduced pump performance and efficiency and to pump damage. Poor intake flow patterns can create conditions where cavitation occurs that can lead to extensive pump damage.

Based on Hydraulic Institute Standards, turbulence can be limited if the following design parameters are followed:

- The distance from the pump intake to the discharge of the incoming sewer should be 6 to 8 times the diameter of the incoming sewer
- The invert of the incoming sewer should be the same as the invert of the pump suction lines. If the inverts are not the same, the wetwell floor should be constructed with a slope not exceeding 1:5 between the two inverts
- The approach velocity to the pump suction should be limited to approximately 1.5 feet per second (fps)
- The flow velocity in the suction line itself should be limited to approximately 4 fps
- Pumps and their intakes should be so configured that the flowlines to the pumps do not impinge on each other when the pumps are operating.

3.1.2 Wetwell Analysis

As seen in Figure 2, the wetwell for the Main PS does not meet these basic criteria. This is not surprising. The Main PS was initially designed for discharging a much smaller flow to the Milpitas WWTP. The pumping capacity has been expanded several times and it now discharges to the SJ/SC WWTP.



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2, 22, 6
1, 1

Specific areas of concern are as follows:

- The distance from the incoming sewer discharge to Pump #3, which is furthest away is only 2.2:1 and is much less than the recommended 6-8:1
- The incoming wastewater drops suddenly with no smooth transition to the pump suction invert
- An approach velocity of 1.5 fps would limit the maximum capacity of the wetwell to 16-20 MGD

A suction velocity of 4 fps limits the pump discharge to 5.5 fps. As these pumps are designed to operate at 13.55 MGD, the resulting suction velocity is approximately 15 fps.

Another problem pertains to the basic configuration of the wetwell. The incoming flow is directed directly to Pump No.3 at a high velocity. This can force debris into this pump when it is not operating. In fact, before, the new grinder structure was constructed there were reports of lumber and other debris being regularly lodged in the impeller of Pump #3. The severity of this problem has decreased with the installation of the new grinder structure.

When Pump #3 is not operating, the incoming flow hits the wetwell wall near Pump # 3 and swirls both clockwise and counterclockwise. This together with the inlet drop creates turbulence that impacts all pumps.

Another problem with this layout is that the pump suction lines are very close to each other and there is no baffling between them. Therefore the inlets can adversely impact each other.

These problems, which cannot readily be corrected, limit the effective long-term capacity of this wetwell to approximately 20 MGD. While the wetwell can handle higher flows on an intermittent basis, it would be problematic if these flows were to occur daily due to the numerous design deficiencies.

3.2 Vibration Testing Results

Before initiating this project, the City of Milpitas stated their concerns regarding cavitation of the pumps under certain operating conditions. This was investigated by conducting vibration tests of the pumps under varying operating conditions and different wetwell elevations. JAC Associates in October 2000 conducted these vibration tests and the results are contained in Appendix C.

Before presenting the conclusions, descriptions of the testing protocol need to be presented. Vibration readings were taken at four points on each pump. These points were:

- MODE – Motor Opposite Drive End, i.e. top of the motor
- MDE – Motor Drive End, i.e. motor at output shaft

- PDE – Pump Drive End, i.e. at pump shaft
- PODE – Pump Opposite Drive End, i.e. bottom of pump

Vibration measurements were made in different directions (horizontal, vertical, and axial) and at different frequencies (cycles per minute – CPM). The lateral movement of the equipment at these various locations and frequencies was not measured; rather the speed to get to the maximum displacement was measured in inches per second (IPS). This is simply one convention used in vibration analysis.

The Hydraulic Institute has published a standard for acceptable levels of vibration. This standard is 0.17 IPS. Page 4 of the vibration report contained in Appendix C presents the maximum vibration measured under various operating conditions. N/A indicates that no reading was taken, and the small dash (-) indicates that a reading was taken, but that it was less than 0.01 IPS. Pages 5 through 29 are graphs of the vibration envelopes under these operating conditions.

Conclusions that can be drawn from this data include:

- Under all monitored conditions, the measured vibration was less the HI Standard
- In general, the measured vibration decreased as the motor rpm decreased
- The measured vibration increased when pairs of pumps were run together
- Vibration increased slightly during low speed operation for Pump #1 when the wetwell was low.
- Pump # 4 exhibited the greatest overall vibration.

The fact that the measured vibration increases when combinations of pumps are run could indicate that cavitation increases when pairs of pumps are run. However, the severity of the cavitation cannot be determined from these tests. A physical inspection of the pumps must be undertaken to determine the magnitude of the cavitation that has occurred.

This report indicates that there is a possible motor bearing issue associated with Pump #4, but that the measured vibration is within acceptable limits. The report further recommends that vibration monitoring be done annually as preventive maintenance. If monitoring is performed annually, and the resultant vibration envelopes compared to the baseline envelopes produced in this report, then problems can be identified before they become serious. No additional vibration analysis has been performed since October 2000.

One problem that was noted in October 2000 pertained to the operation of Pump #3. Pump #3 was inoperable due to reports of severe vibration. Pump #3 could not be operated during this test period as the bracket between the top of the pump motor and the wall was broken. As of October 2003 this bracket remains broken and no repairs have been made to the pump or motor. Pump #3 is still inoperable.

Section 4: HYDRAULIC MODEL

4.1 Background

A hydraulic model of the main interceptor sewers was developed using HYDRA™ Version 6.1.6.5. The purpose of this hydraulic model was to determine if any sewer overflows would occur under extreme operating conditions. The extreme operating conditions included:

- The wetwell water surface elevation was set at elevation – 5.0
- The design flow used was 40 MGD
- A 1-foot headloss was assumed to occur through the new grinder structure.

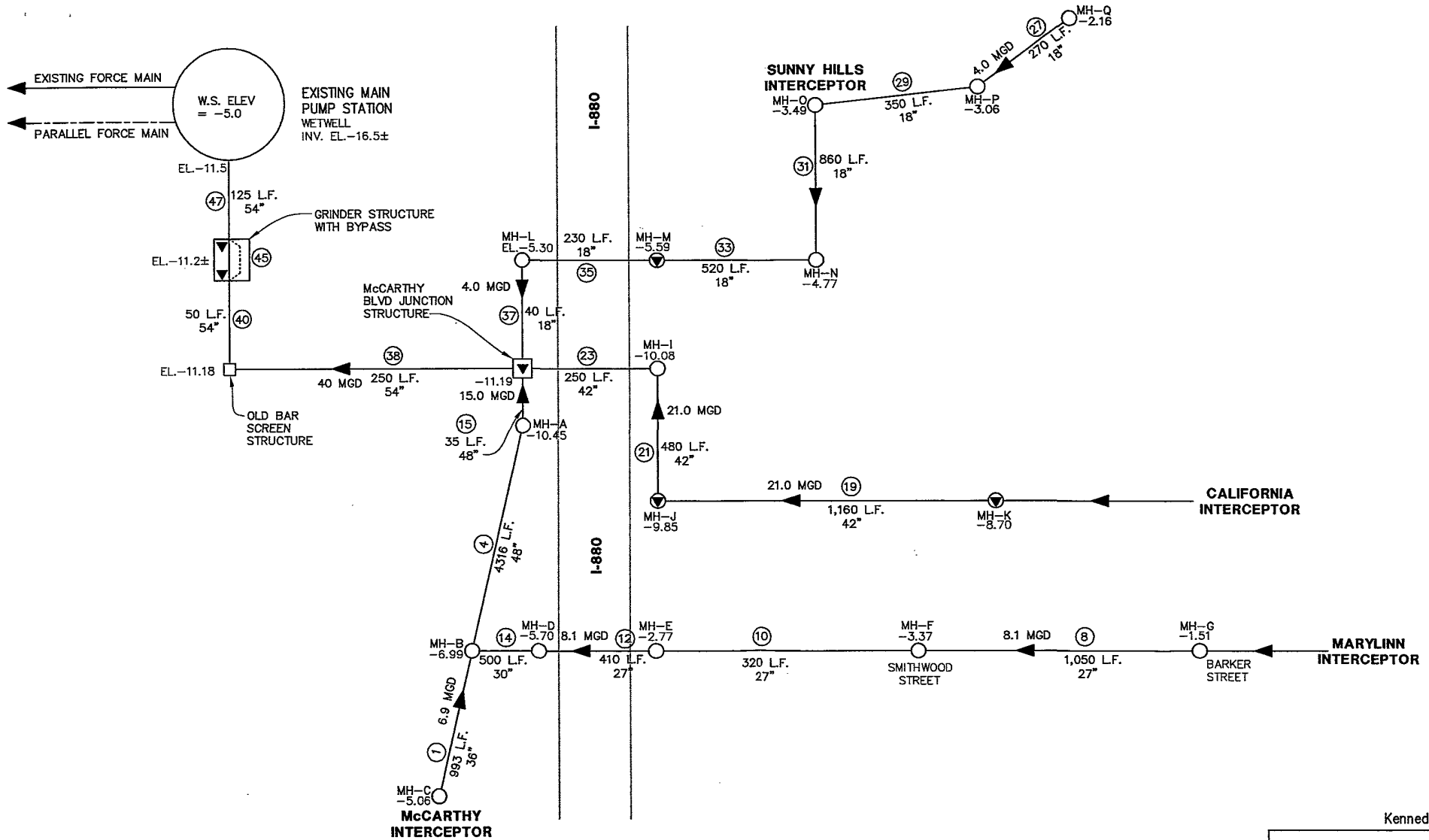
A schematic showing the input variables used for this model is presented as Figure 3.

4.2 Results

Appendix D contains the results of the model run for the extreme conditions defined above. These results are summarized in Table 4. In interpreting the results in Appendix D, 20 feet needs to be subtracted from the elevations shown. The computer model would not accept negative elevations; therefore, 20 feet had to be added to all known elevations in order to make insure that all elevations had positive values

These results indicate that while numerous manholes are surcharged, no sewage overflows onto the ground occurs. This is due to the depth of the interceptors in the vicinity of the Main PS.

Another item to be noted is that no additional headloss was accounted for at the McCarthy Boulevard Junction Structure. At this location, the McCarthy Boulevard, California, and Sunny Hills Interceptors come together. It appears that this junction structure consists of a manhole that the three interceptors discharge into, without the use of smooth channels. This would create significant turbulence in this structure and result in additional headloss.



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 HYDRAULIC MODEL SCHEMATIC**

JUNE 2002

TABLE 4: SUMMARIZED HYDRAULIC MODEL RESULTS

LOCATION	INV. ELEV.	RIM ELEV.	HGL ELEV @ 40 MGD
McCarthy Interceptor			
MH-A	-10.45	10.00	-3.14
MH-B	-6.99	9.50	-2.01
MH-C	-5.06	9.00	-1.68
Marrylinn Interceptor			
MH-D	-5.70	10.50	-1.47
MH-E	-2.77	12.00	-0.80
MH-F	-3.77	12.50	-0.52
MH-G	-1.51	13.00	1.20
California Interceptor			
MH-I	-10.08	9.00	-3.05
MH-J	-9.85	9.00	-2.24
MH-K	-8.70	9.00	-0.72
Sunny Hills Interceptor			
MH-L	-5.30	9.50	-3.18
MH-M	-5.59	9.00	-2.36
MH-N	-4.77	9.00	-0.56
MH-O	-3.49	7.00	2.75
MH-P	-3.06	8.00	4.29
MH-Q	-2.16	8.00	5.31

SECTION 5: MAIN PUMP STATION – ALTERNATIVE DESIGNS

5.1 Introduction

The fundamental question that needs to be addressed is what steps can be taken to increase the capacity of the wetwell and pump station to handle the future peak wet weather flow of 40 MGD while still handling the current nighttime dry weather flow of approximately 5 MGD. The Main PS as currently configured cannot efficiently pump both flows.

The Main PS as currently configured can pump both the nighttime dry weather flows of 5 MGD and the current peak wet weather flow of approximately 24 MGD. However, the pumping is not being done in the most efficient manner because of the need to run the 250-hp pumps at an extremely low speed to pump the dry weather nighttime flows.

One point that needs to be made is that the extreme wet weather (30-40 MGD) flows currently happen very infrequently. An intense rainstorm of a relatively long duration is necessary to cause these flows, and the flow drops off rapidly once the rainfall event ceases. Therefore, these extreme wet weather flows are outside of the normal operating points.

Realistically the options for improving the pumping capacity of the Main PS are:

- Alternative 1 – Abandon the existing Main PS, and construct a new pump station that is designed to accommodate the existing and projected highly variable flows
- Alternative 2 – Construct a parallel pump station that under normal conditions would alternate with the existing pump station, and under peak conditions would operate in parallel with the existing pump station
- Alternative 3 – Reconfigure the existing Main PS

5.1.1 Alternative 1 – Abandon Existing and Construct New Pump Station

Alternative 1 is the most expensive alternative. However, it should be recognized that the Main PS was initially designed 40 years ago to pump to the headworks of the Milpitas Wastewater Treatment Plant and not to pump to the SJ/SC WPCP. If the Main PS had been designed initially to pump to the SJ/SC WPCP, the design concept would have been different.

For example the City of Redwood City discharges to the wastewater treatment plant of the South Bayside System Authority (SBSA). All of Redwood City except for Redwood Shores, the Town of Woodside, and portions of Atherton and unincorporated areas of San Mateo County discharge to the Maple Street Pump Station (PS) into the SBSA Interceptor Sewer.

Flows from the Maple Street PS are very similar to those of Milpitas' Main PS. The average daily dry weather flow is 11-13 MGD and the peak wet weather flow is 30-35 MGD. The minimum nighttime dry weather flow is approximately 4 MGD.

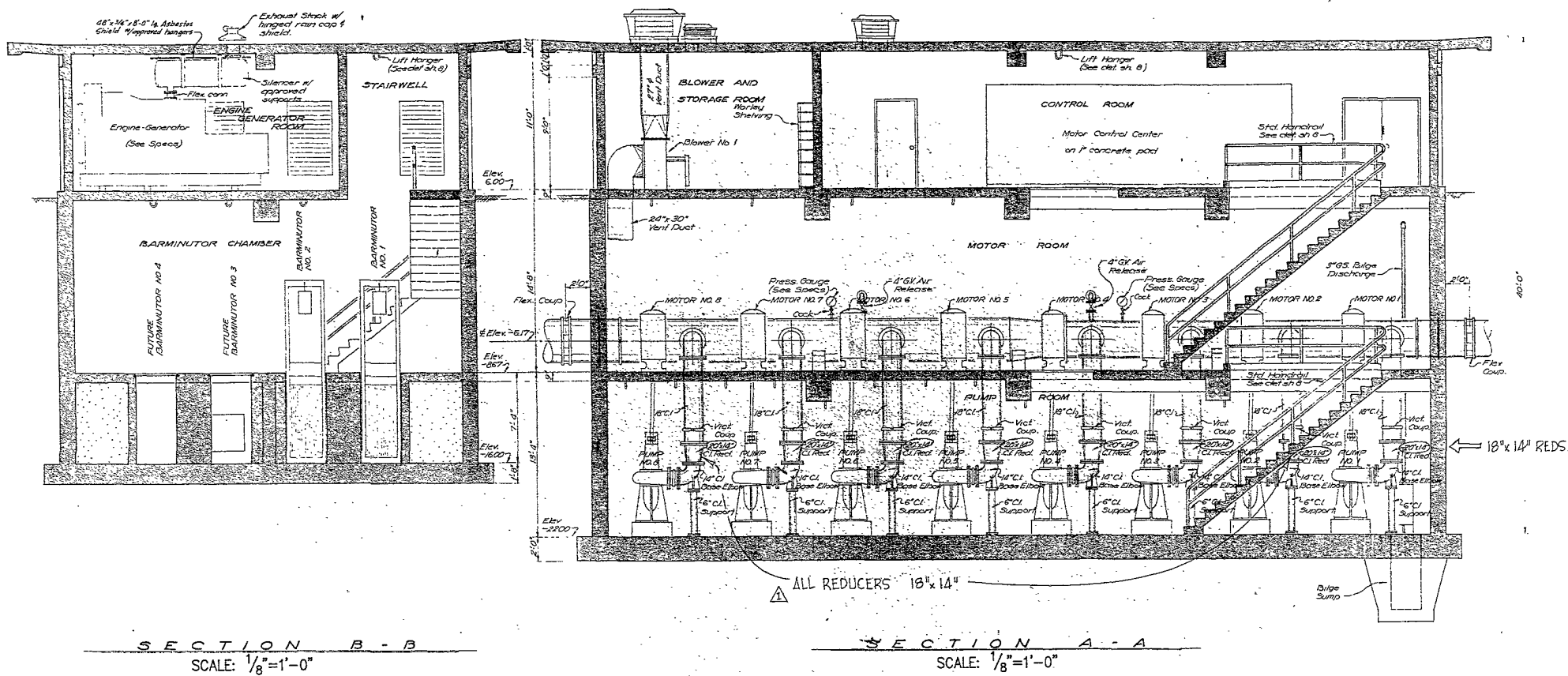
However, the configurations of the two pump stations are vastly different. Figures 4 and 5 are the layouts for the Redwood City Maple Street Pump Station, and it is representative of the layout of a new Main PS that would be designed to handle a flow of 40 MGD. The Maple Street PS is a 3-story pump station that has an overall footprint for the pumping area, exclusive of the barminutor room, of approximately 70-feet by 30-feet.

Originally the Maple Street PS was planned to house 8 pumps, 4 of 75 horsepower and 4 of 100 horsepower. Currently it is configured with 6 pumps, each of 100 hp with a maximum discharge of 4.7 MGD each. Each of these pumps has variable frequency drives on them. At the low nighttime dry weather flow of approximately 4 MGD, one pump operates as the flow increases additional pumps come on and their speed is adjusted to maintain a constant wetwell elevation.

Utilizing a similar approach a new pump station could be constructed as shown on Figure 6. The cost to construct a new Main PS that would contain 8 pumps each capable of discharge 5.0 MGD is presented in Table 5, and the detailed breakdown is presented in Appendix F.

TABLE 5: ESTIMATE OF PROBABLE COSTS OF CONSTRUCTION – ALTERNATIVE 1

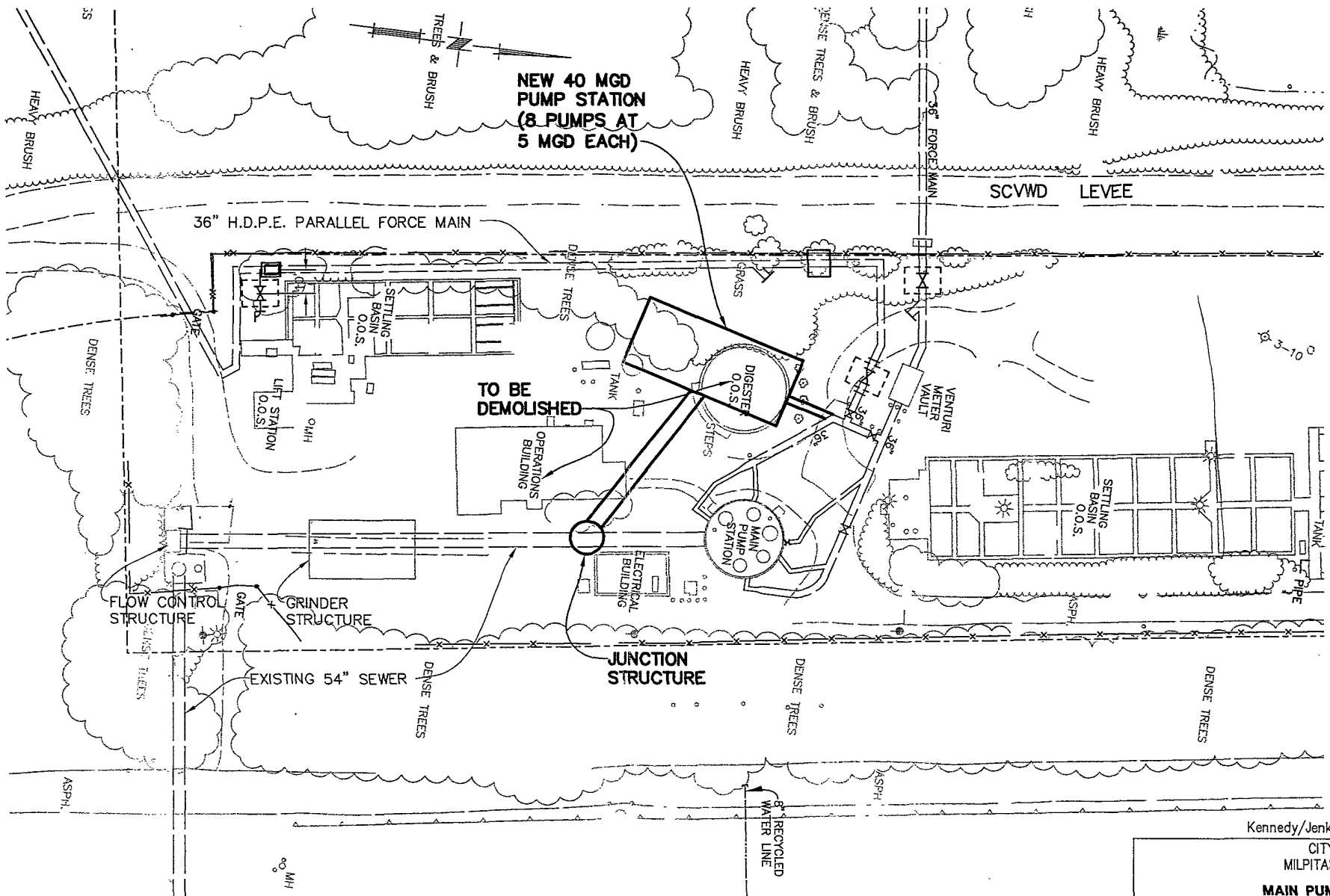
ITEM	COST
Mobilization/Demobilization	\$150,000
Demolition	\$150,000
Structural	\$882,767
Mechanical	\$1,124,792
Electrical	\$685,000
	\$2,992,559
Taxes	\$124,768
Contractors OH&P	\$467,599
+20% Contingency	\$717,074
Total	\$4,302,000



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**MAPLE STREET PUMP STATION
STATIC
SECTIC**

APR 200
FIGURE NO.



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MAIN PUMP STATION
ALTERNATE NO.

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FIGURE

5.1.2 Alternative 2 – Construct Parallel Pump Station

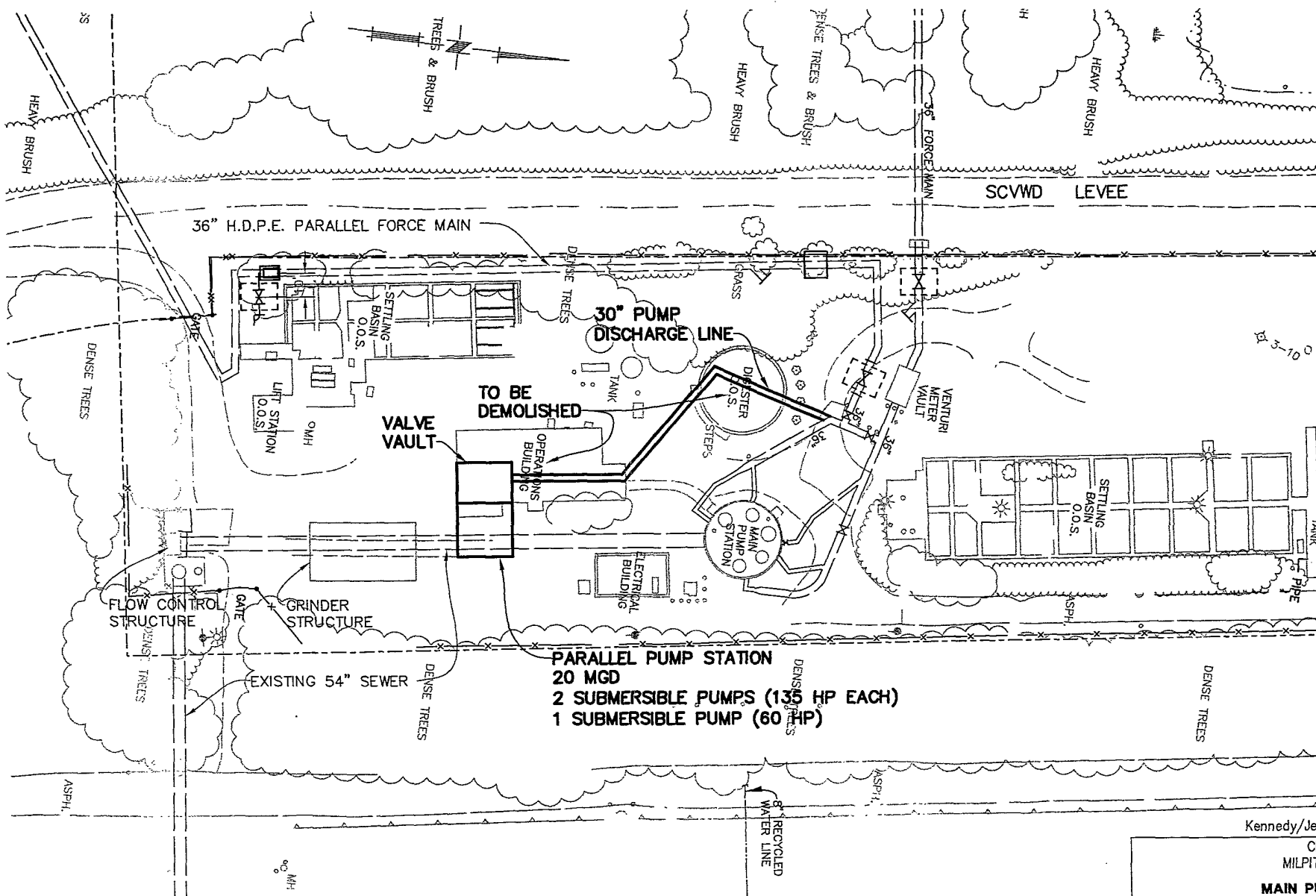
In this alternative, a second pump station would be reconstructed with a maximum pumping capacity of 20 MGD, and the existing Main PS would be reconfigured to provide a capacity of 20 MGD.

The new pump station would be designed as a submersible pump station, and be located as shown on Figure 7. It would contain 3 pumps. One pump would be a 60 hp pump for low flow situations and two 135 hp pumps would be used for high flows. Each of the 135 hp pumps would be capable of handling the peak dry weather flow. A cost estimate for this alternative is presented in Table 6, and the detailed breakdown is presented in Appendix F.

TABLE 6: ESTIMATE OF PROBABLE COSTS OF CONSTRUCTION – ALTERNATIVE 2

ITEM	COST
Mobilization/Demobilization	
Demolition	
Structural	
Mechanical	
Electrical	
Subtotal	
Taxes	
Contractor's OH&P	
+20% Contingency	
Total	

This alternative raises a question regarding the installed horsepower of the existing Main PS. The Main PS has 4 pumps of 250 hp each (1000 hp total), while the proposed parallel pump station utilizes 2 –135 hp pumps (270 hp total) to pump 20 MGD. If the maximum amount pumped were 40 MGD, then it would appear that approximately 540 hp is adequate, rather than the 1000 hp that is installed.



Kennedy/Jenks Consultants
CITY OF MILPITAS
MILPITAS, CALIFORNIA

**MAIN PUMP STATION
ALTERNATE NO. 1**

985002
JUN 20

FIGURE

Figure 8 shows the system curve for a single force main (both force mains have similar system curves). Figure 8 also shows where the pump curves (See Appendix E) intersect the system curve for the proposed submersible pumps. The operating points for the submersible pump station are presented in Table 7.

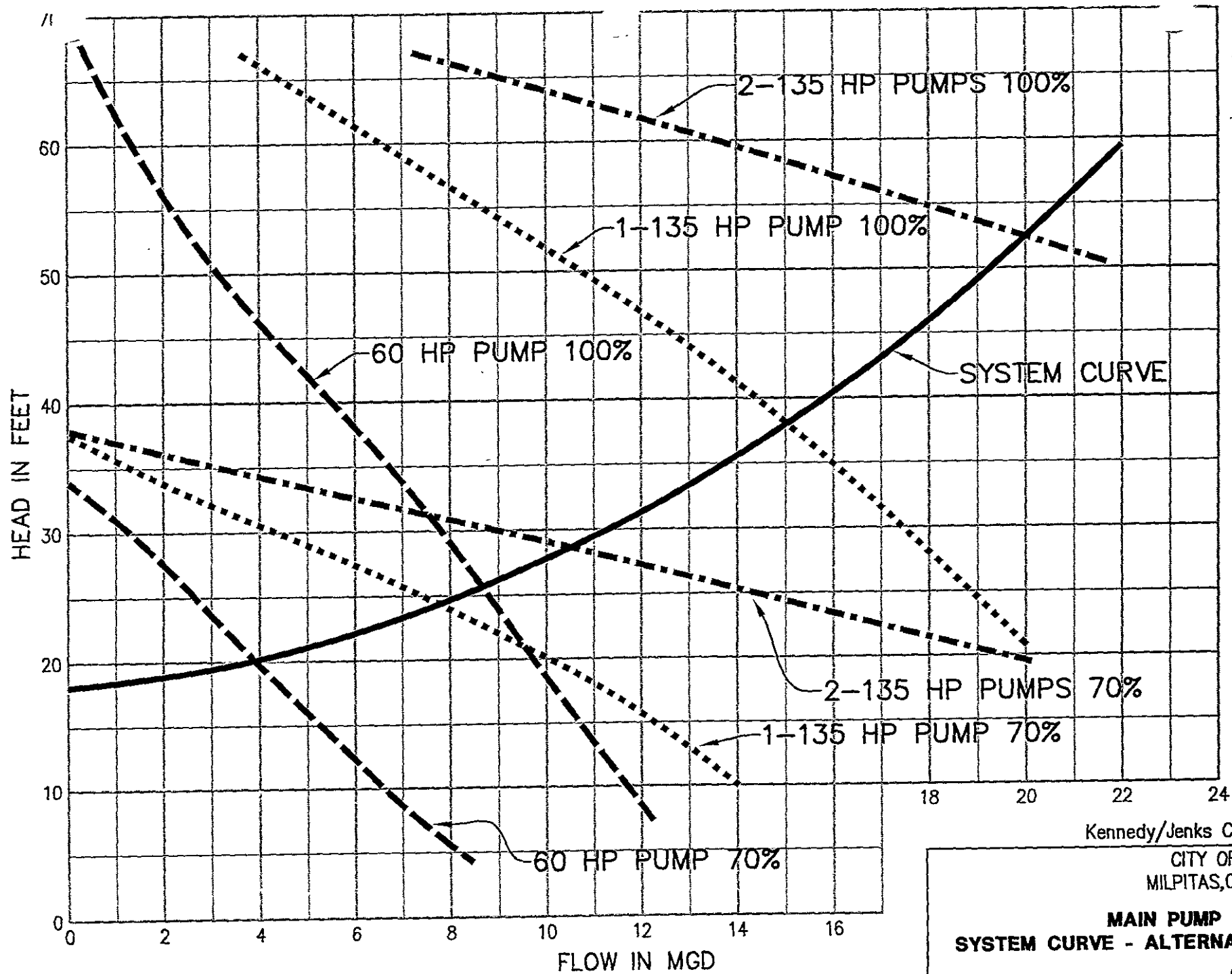
TABLE 7: SUBMERSIBLE PUMP STATION OPERATING POINTS

PUMP HP	# PUMPS	SPEED	FLOW (mgd)	HEAD (feet)
60	1	70%	4	20
60	1	100%	8.5	25.5
135	1	70%	7.8	24.5
135	1	100%	15	38
135	2	70%	10.7	29
135	2	100%	20	52.5

For Alternative 2, each pump station is designed to pump a maximum of 20 MGD through a single force main. The existing Main PS is designed to pump 30 MGD through a single force main. Based on the 4 May 2000 Carollo memo, the operating points for the operation of multiple pumps at 90% efficiency, pumping into a single force main is as follows:

- One pump – 16 MGD @ 40-feet TDH
- Two pumps – 24 MGD @ 65-feet TDH
- Three pumps – 28.5 MGD @ 78-feet TDH

This memo also shows that if three pumps were operated at 100% speed, they would produce 30 MGD at 95 TDH. It appears that these pumps were selected on trying to match the 30 MGD operating point with a single force main in service. This results in the pumps being oversized for normal operating conditions with a single force main in service. This becomes an even more significant issue now that two force mains are in service. With the completion of the parallel force main it is more appropriate to consider the overall pumping facility to consist of two pumping stations and a two force mains. Each pumping station and associated pumps can be designed as 20 MGD stations. This would be the same whether there are two separate pump stations or if the existing station is valved so that a maximum of two pumps can discharge into a single force main.



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CITY OF MILPITAS
MILPITAS, CALIFORNIA

**MAIN PUMP STATION
SYSTEM CURVE - ALTERNATE NO.2**

985002.04
JUN 2002

FIGURE 8

5.1.3 Reconfigure Existing Main PS

As was pointed out in the previous section the installed horsepower of the existing Main PS is too large now that both force mains are operational. Further the existing configuration utilizing 4-250 pumps does not adequately address low flow conditions when it is necessary to only pump 5 MGD. The total flow of 40 MGD could be pumped utilizing the two force mains, by replacing the 250 hp pumps with 125 hp pumps. Each force main would pump approximately 20 MGD.

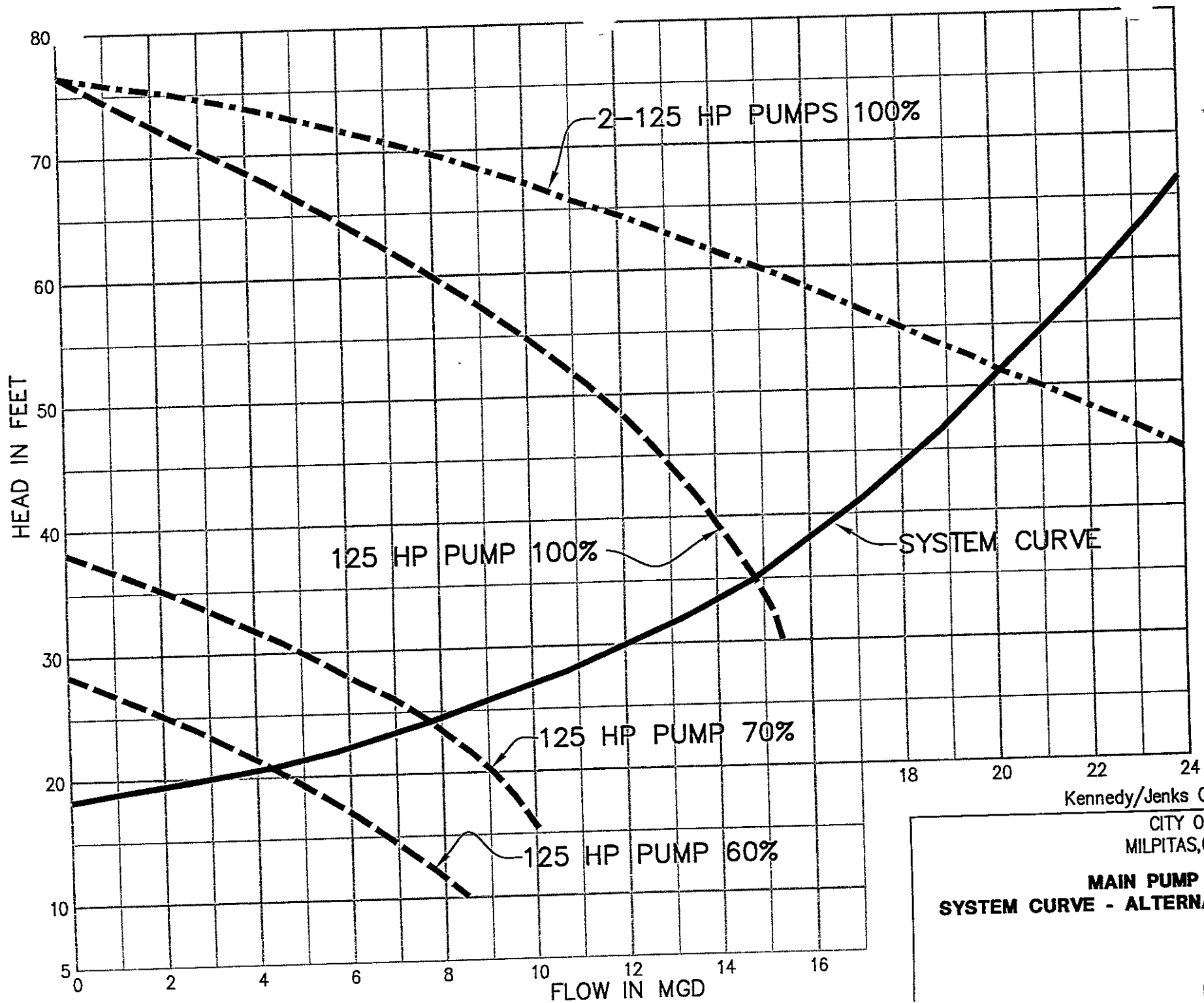
Figure 9 is a pump curve showing the operation of two 125 hp pumps in a single force main. A single 125 hp pump could run at 60% speed for low flow conditions, and would operate at 100% speed for typical maximum day dry weather conditions. Under wet weather conditions two pumps would discharge into a single force main. Under maximum peak wet weather flows (20-40 MGD), up to four pumps could be operated, but this would require the utilization of two force mains.

The cost estimate for this option is presented in Table 8.

TABLE 8: ESTIMATE OF PROBABLE COSTS OF CONSTRUCTION – ALTERNATIVE 3

ITEM	COST
4-125 hp Pumps Equipment	\$150,000
4-125 hp Pumps Installation	\$80,000
Piping Modifications	\$50,000
Electrical modifications	\$60,000
Subtotal	\$340,000
+20% Contingency	\$68,000
Total	\$408,000

By retrofitting the existing pump station with pumps with less horsepower and running them at higher speeds, some energy saving can be achieved. It is estimated that the current annual power cost could be reduced by approximately \$7,400 annually with the installation of 125 hp pumps. Energy savings alone would not be sufficient justification for installing the smaller pumps.



Kennedy/Jenks Consultants

CITY OF MILPITAS
MILPITAS, CALIFORNIA

**MAIN PUMP STATION
SYSTEM CURVE - ALTERNATE NO.3**

985002.04
AUG 2002

FIGURE 9

However this option does not provide the operational flexibility that currently exists. Currently 3-250 hp pumps can pump approximately 40 MGD using both force mains. This same capacity would require 4-125 horsepower pumps. This implies that all pumps must be operational at all times, or that a fifth 125 hp pump be installed as a standby unit.

5.2 Recommended Alternative

The fundamental problem with Alternatives #2 and #3 is that these alternatives continue to utilize the existing pump station that was never designed for its current application, and is over 40 years old. Major modifications have been done throughout its life, but its replacement should be planned in order to accommodate future growth in the City.

Repairs are required at the existing facility. Pump #3 needs immediate attention. The broken support bracket needs to be repaired and the pump started to verify the extent of repairs required. As three pumps are required to handle extremely high flows (30-40 MGD) and Pump #3 is off-line, there is no pump redundancy under extreme conditions.

The repair of Pump #3 will also permit the other pumps to be taken off-line for repair. A program needs to be established for the repair and maintenance of the other pumps based on operator input.

The long-term solution is to abandon the existing Main PS and construct a new facility. The City of Milpitas should begin the budgeting process for the construction of a new pump station that would be constructed within the next 5 years. The estimates of the probable cost of construction contained in this report are planning level cost estimates and their accuracy is between -20% and +50%. One of the first steps of the budgeting process should be to obtain a more accurate estimate of the cost of construction.

Section 6: REVIEW OF MAIN PUMP STATION CONTROLS AND STRATEGY

6.1 Existing Operation – Single Force Main

The operation of the existing wetwell is relatively simple. All pumps are operated by variable speed drives. Pumps are turned on or off based on various set points as indicated in Table 3, and a nearly constant water surface elevation is maintained.

Pump speed is limited to 90% in order to maintain the required Net Positive Suction Head (NPSH). A relatively high wetwell level is maintained to maximize submergence over the pump intakes to minimize vortexing and associated cavitation issues. Pump speed is also set at a minimum of 50%.

No changes to existing operations are proposed when a single force main is on-line.

6.2 Existing Operation – Dual Force Mains

The operational staff at the Main Pump Station has expressed a preference for the manual operation of the dual force main system. Staff will alternate the operation of the two force mains and will manually direct which flow goes into which force main.

The detailed start-up procedure for alternating the force mains or for putting a second force main in service is presented in the Operations and Maintenance Manual developed for this project. This procedure is based on manual operation, which is the operator's stated preference.

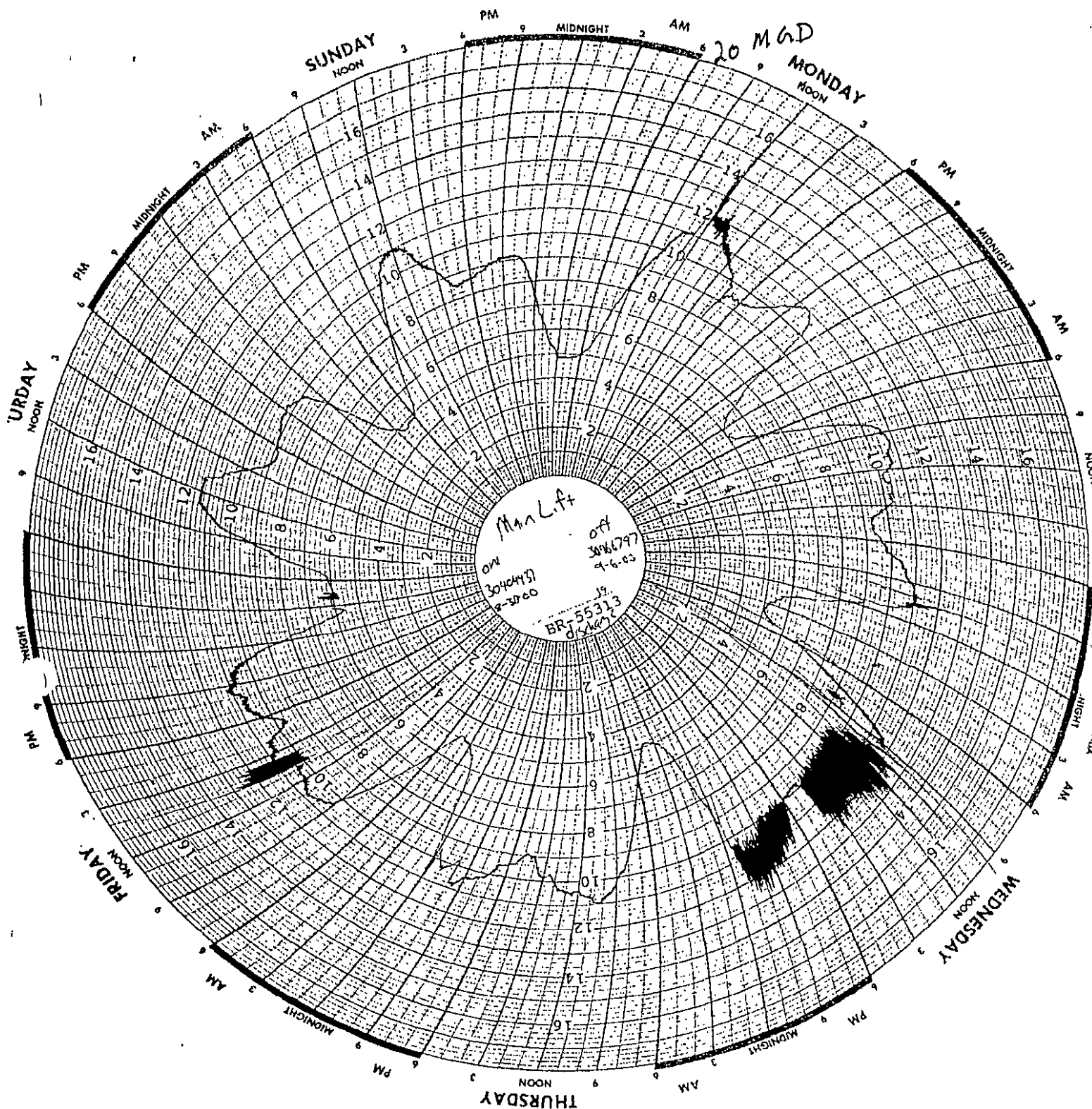
This is adequate for normal dry weather flows, but may not be sufficient for peak wet weather flows when the operation of more than two pumps is required. In this instance, the automatic opening of the appropriate pinch valve should be considered based on the startup of a third pump. If the operation of a third pump occurred when staff was present, the second force main could be brought on line manually. However, if high flows occurred when no one was present then all the flow would go into one force main. Maintenance staff should consider implementing an automatic high flow operation program.

Modulating pinch valves were installed on the old and new force mains at the Main PS. The design rationale for the installation of the modulating valves was that they could be used to control discharge based on start-up. Operational experience gained since the facilities were put on line, shows that this modulating feature is not needed in the current operational mode as discharge into the force mains can be controlled using pump speed.

Appendix A

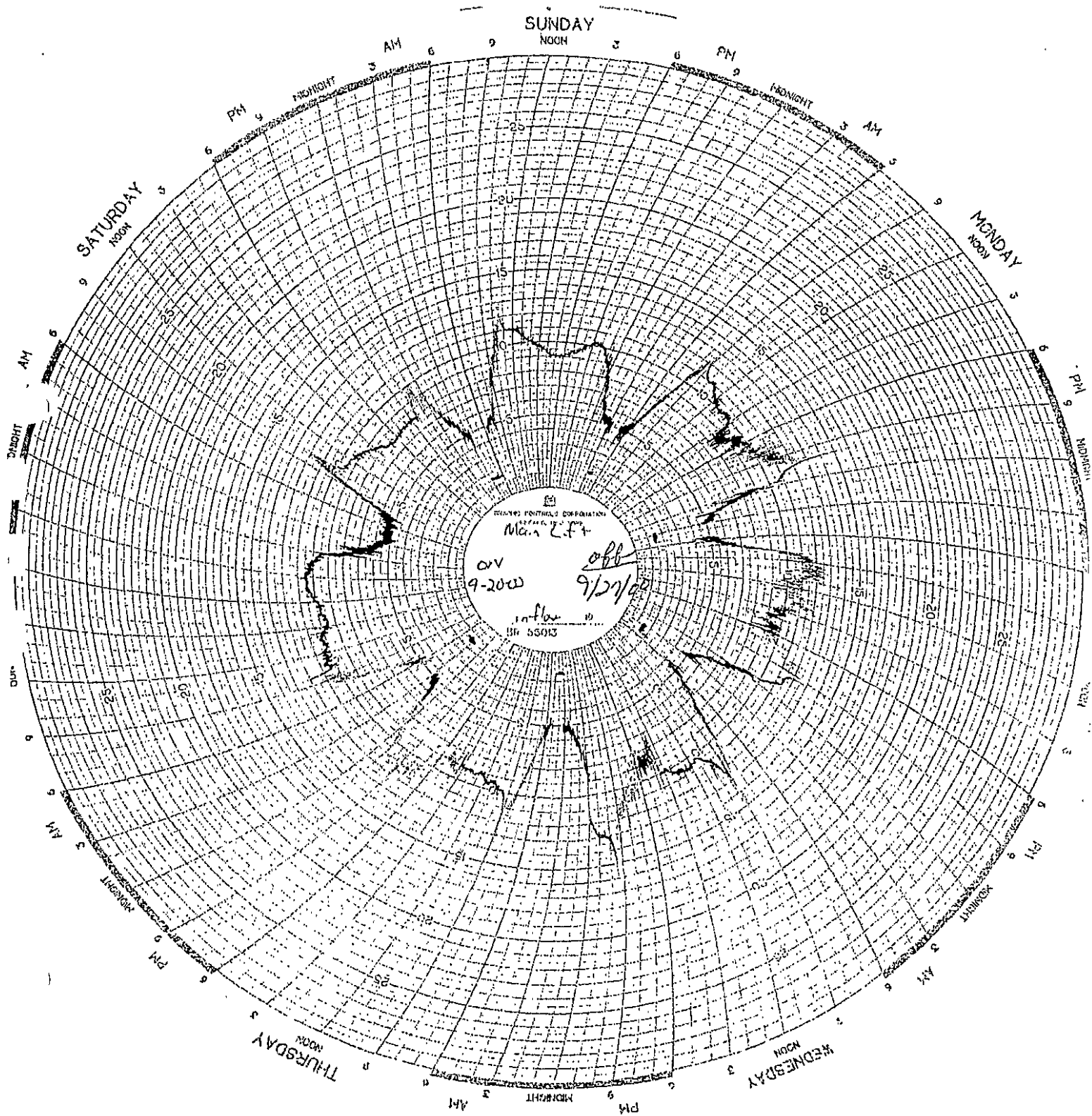
August/September 2000 Circular Charts

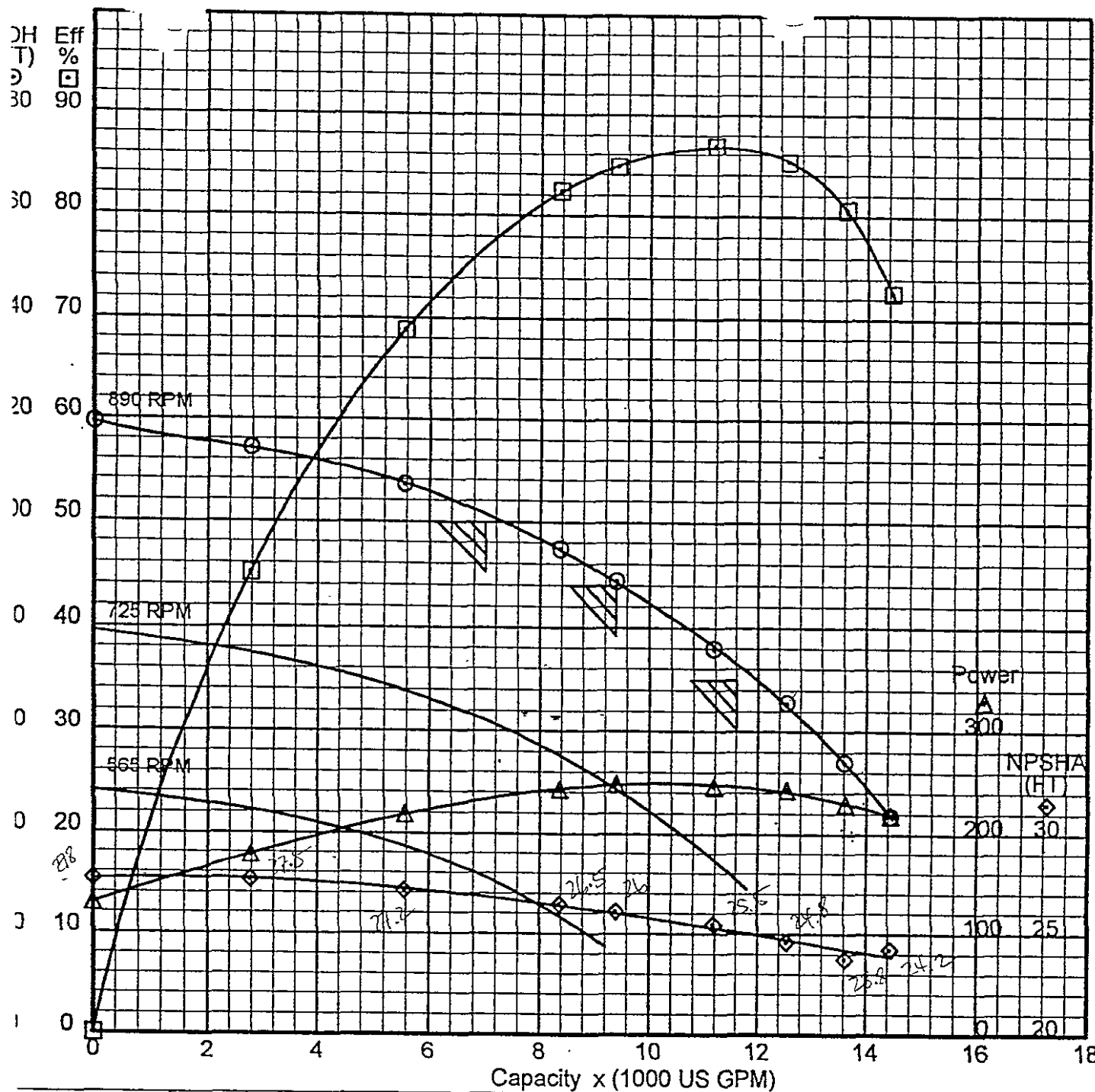
Pump Curves



Post-it® Fax Note 7671		Date 9/15/00	# of pages 2
To TOM YEAGER	From MCA CUMMINGS		
Co./Dept.	Co.		
Phone # 650-852-2500	Phone # 408-586-3349		
Fax # 650-852-8521	Fax # 408-586-3305		

Venturi meter





INGERSOLL-DRESSER PUMP COMPANY PUMP TEST DATA

RPM	GPM	TDH	BHP	Eff
896	0.0	120.8	132.3	0.0
894	2792.7	115.2	180.1	45.1
892	5585.4	107.6	220.5	68.8
891	8378.1	95.0	244.1	82.3
890	9411.5	88.8	248.8	84.8
891	11195.7	76.0	247.3	86.9
891	12556.1	65.7	244.1	85.3
892	13650.8	54.2	231.6	80.6
892	14482.5	43.7	220.5	72.6

I CERTIFY THAT WITHIN THE ACCURACY OF
THE TEST INSTRUMENTATION, THIS TEST
REPRESENTS THE PERFORMANCE OF
16MNF25 PUMP 9811MS000709-1

Daniel A. Dorne

SP.GR.: 1.000

CASING DATA

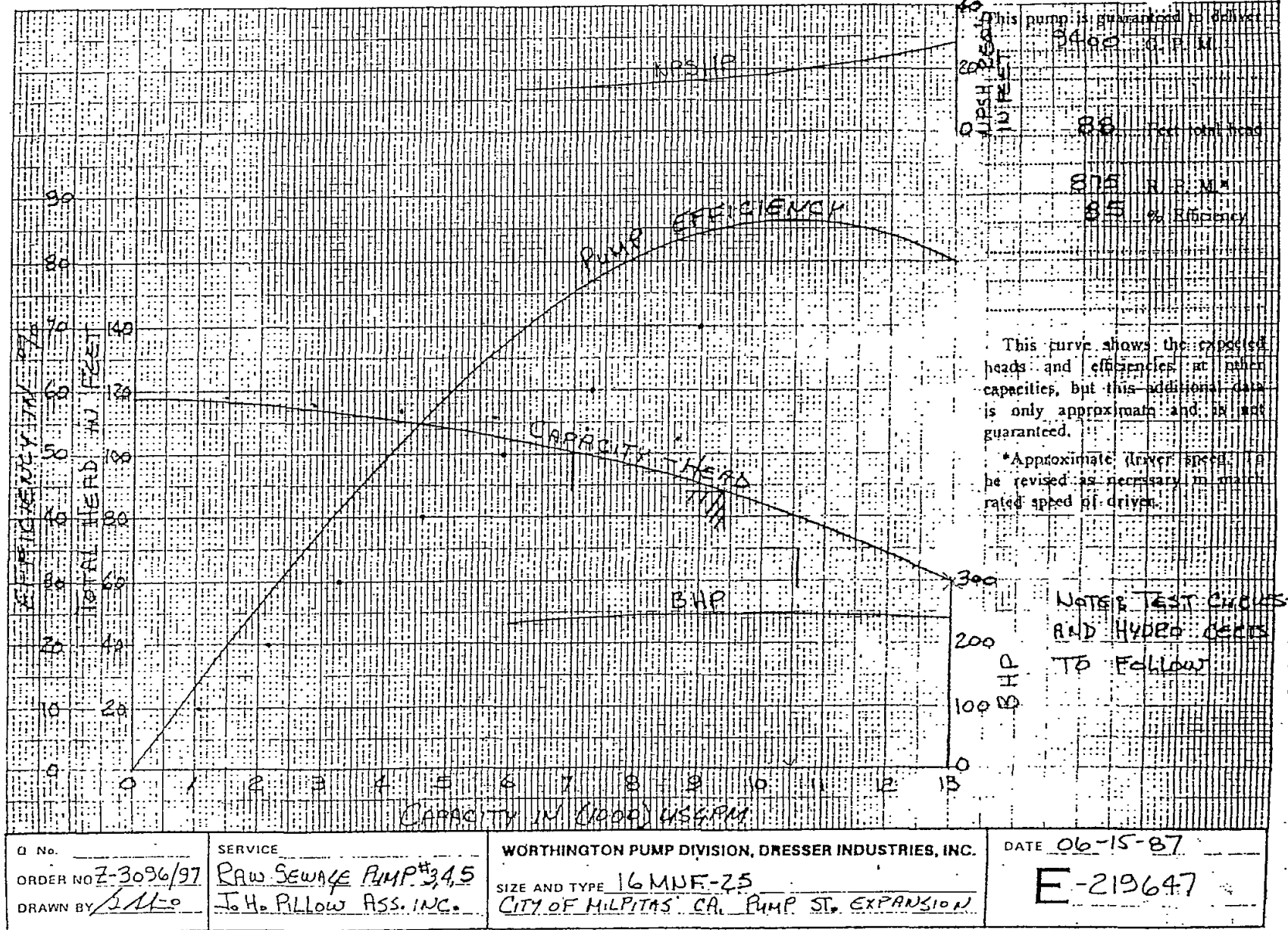
A278 CL35 MATERIAL	SIS-3 FINISH	- TONGUE
-----------------------	-----------------	-------------

IMPELLER DATA

A278 CL35 MATERIAL	1A FINISH	- DISC. TIPS
UB5510B	B-22	22.88"
PATT. NO.	COMB. NO.	DIA

16MNF25 PUMP	1 STAGES	S000709 ORDER NO	9811MS000709-1 SERIAL NO	2DEC98 DATE	SSA TEST	<i>D A 12</i> APPROVED	200H/900R, #30 TEST DRIVER	16x10.5, #29 VENTURI PLOTTED	890 PUMP	T-S000709-1A CURVE NO
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Figure 2 - Manufacturer Pump Curves



Appendix B

Carollo Memo Dated 4 May 2000

deaerated. The curve points are determined when the suction pressure is low enough to cause a loss of 3 percent in the discharge head at the measured flow compared to the case with adequate



2700 Ygnacio Valley Road, Suite 300, Walnut Creek CA 94598
Phone (925) 932-1710 Fax: (925) 930-0208

Fax Cover/Memo

DATE: May 4, 2000

TIME: am / pm

Please deliver this and the following pages: (PAGES Incl. THIS page = 5).

If you do not receive all the pages, please phone (925) 932-1710, Extension 3033.

Our FAX PHONE is (925) 930-0208.

To: Eddie Barbosa

At: City of Milpitas

FAX Phone: 408 942-8767 ✓ OK

cc: Lucinda Kraynick, Fax ⁴~~208-942-2391~~ (408) 942-5158

From: Tom Hendrey

Regarding: Main Sewage Pump Station Improvements Project, Project 6071 (Carollo Job 3877A.20)

Estimated Pump and System Curves

MESSAGE:

Per my discussions with Eddie about the need to reduce the maximum speed of the pumps, attached is the pump and system curves for 1, 2 and 3 pumps running in parallel.

These curves were prepared based on the manufacturer's catalog curves for the installed pumps and the system curve information contained in the last master plan we did. I do not know if the system curve was field verified and is thus subject to uncertainty as to its accuracy.

The point of the curves is to illustrate that with only one pump operating, the pump will run into a NPSH problem if operated at full speed. The plots contain:

3 system curves representing a range in wet well level of about 4 feet and a range in estimated system friction loss. The center system curve is the "design" curve at 7 feet wet well level (6 ft on bubbler) and a system friction loss represented by a Hazen-Williams C value of 120.

6 pump curves for the varying speed from 100% down to 60% as labeled.

2 NPSHa, available suction head, curves. The higher NPSHa curve is the calculated static head and friction loss in the pump suction. The lower NPSHa curve is the calculated curve less 10 feet as a safety factor or margin because the manufacturer's NPSHr curve is prepared for ideal conditions and the pump cavitates when operated at the manufacturer's curve.

6 overlaid NPSHr, required suction head, curves adjusted for the varying speeds plotted.

The manufacturer's published NPSHr curve is prepared in accordance with the Hydraulic Institute Standards that require testing under specified and ideal conditions of 60 oF water that has been deaerated. The curve points are determined when the suction pressure is low enough to cause a loss of 3 percent in the discharge head at the measured flow compared to the case with adequate

suction. In other words, at ideal conditions, the NPSH curve represents the beginning of cavitation. A pump should never be continuously operated at or very near the manufacturer's published NPSHr curve. Thus, our recommendation that a 10 feet safety factor be included in the NPSHa curve.

On the one pump curve for 100% speed, Figure 1, the curves show the estimated flow at about 18 mgd and the NPSHa about equal to the NPSHr - not a good place to operate.

Based on casual observations in the field on May 2, 2000, the pumps actually pump nearly 18 mgd at 90 percent speed if the venturi meter is properly calibrated. This indicates that our estimated system curve on the figures shows a somewhat higher resistance than the actual field conditions. Thus, it may be possible to see some pump cavitation at 90 percent speed under field conditions.

Currently, the speed of all four pumps is limited to just under 90% speed by limiting the Micromac 2600 output signal 18.2 milliamps (ma) maximum. A 18.2 ma signal in a range of 4 to 20 ma expected input into the VFD is 89% of the range of the input signal (18.2 is 89% of the way from 4 to 20 ma). The VFDs could run at 100% if they were to receive a 20 ma input signal so the upper speed limitation has been programmed into the Micromac and not the VFDs.

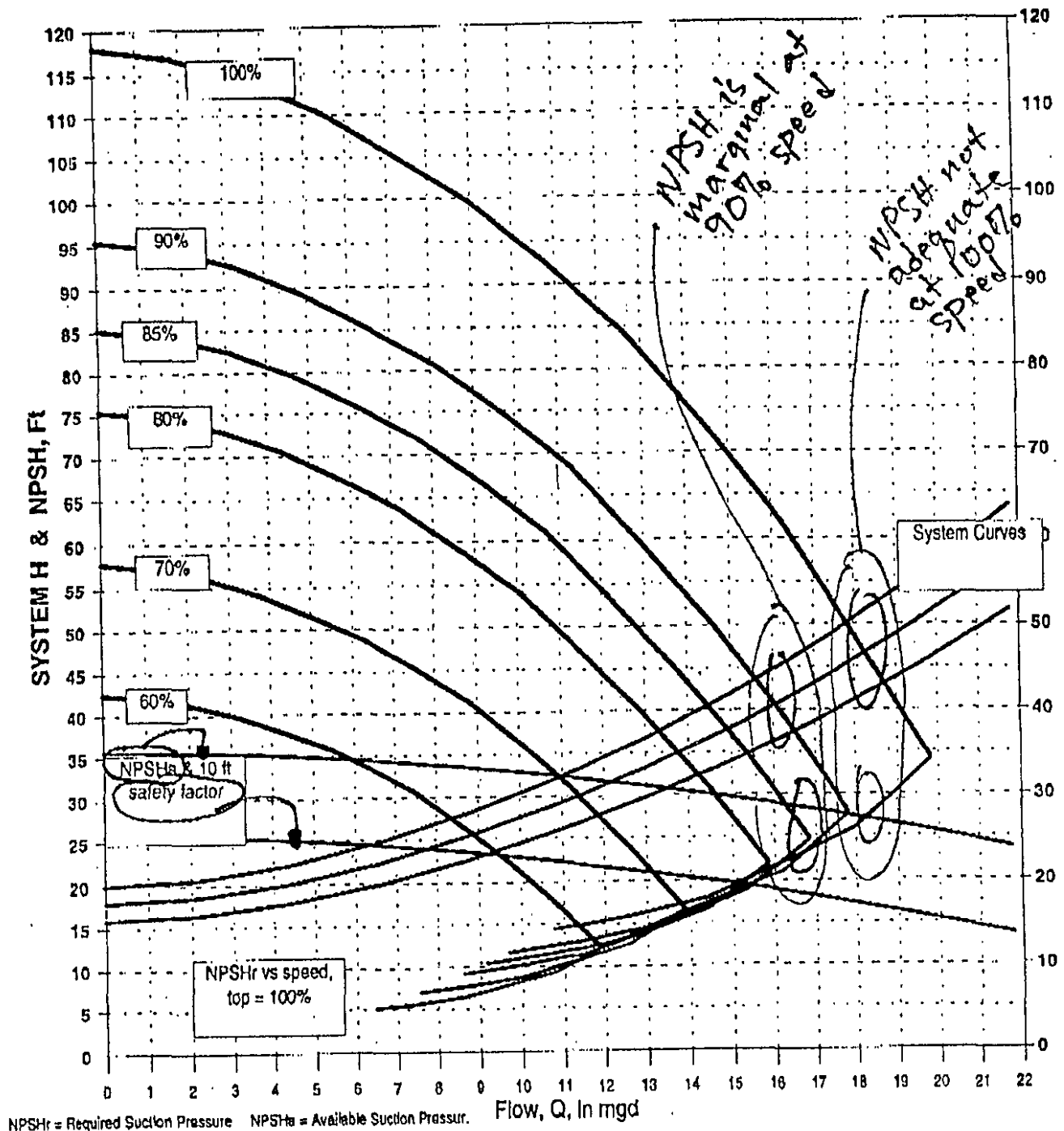
Because of the programming limitations of the Micromac system, all the pumps are limited to the same maximum speed regardless if 1, 2, 3 or 4 pumps are operating. Thus, the control system's limitation reduces the maximum flow the pump station can pump by about 4 mgd with 3 pump operating (the difference between the 90% and 100% curves on Figure 3).

Please call me if you have any questions regarding the attached curves. Please remember, these curves are only estimates and have not been field verified.

You should note that when the second force main is put into service, the system resistance will drop substantially and increase the likelihood of pump cavitation without further reduction in the maximum speed that each combination of pumps can run

Milpitas - Main P.S.
1 Pump into 36" F.M. (est. losses)

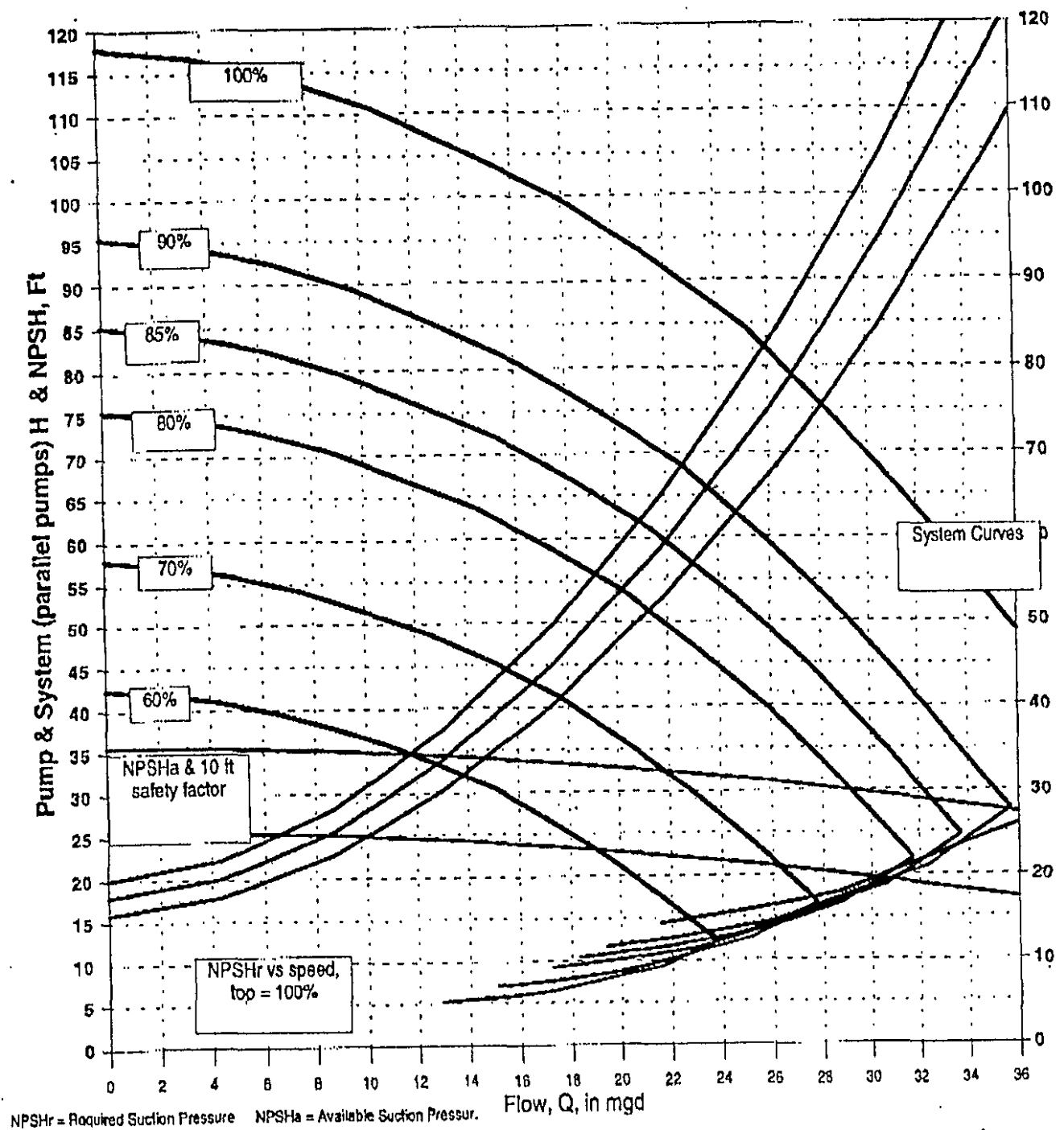
Figure 1



Modified Pump Curves = Actual pump curve less suction & disch. pipe losses; System Curve = FM line losses only.

Milpitas - Main P.S.
2 Pumps Into 36" F.M. (est. losses)

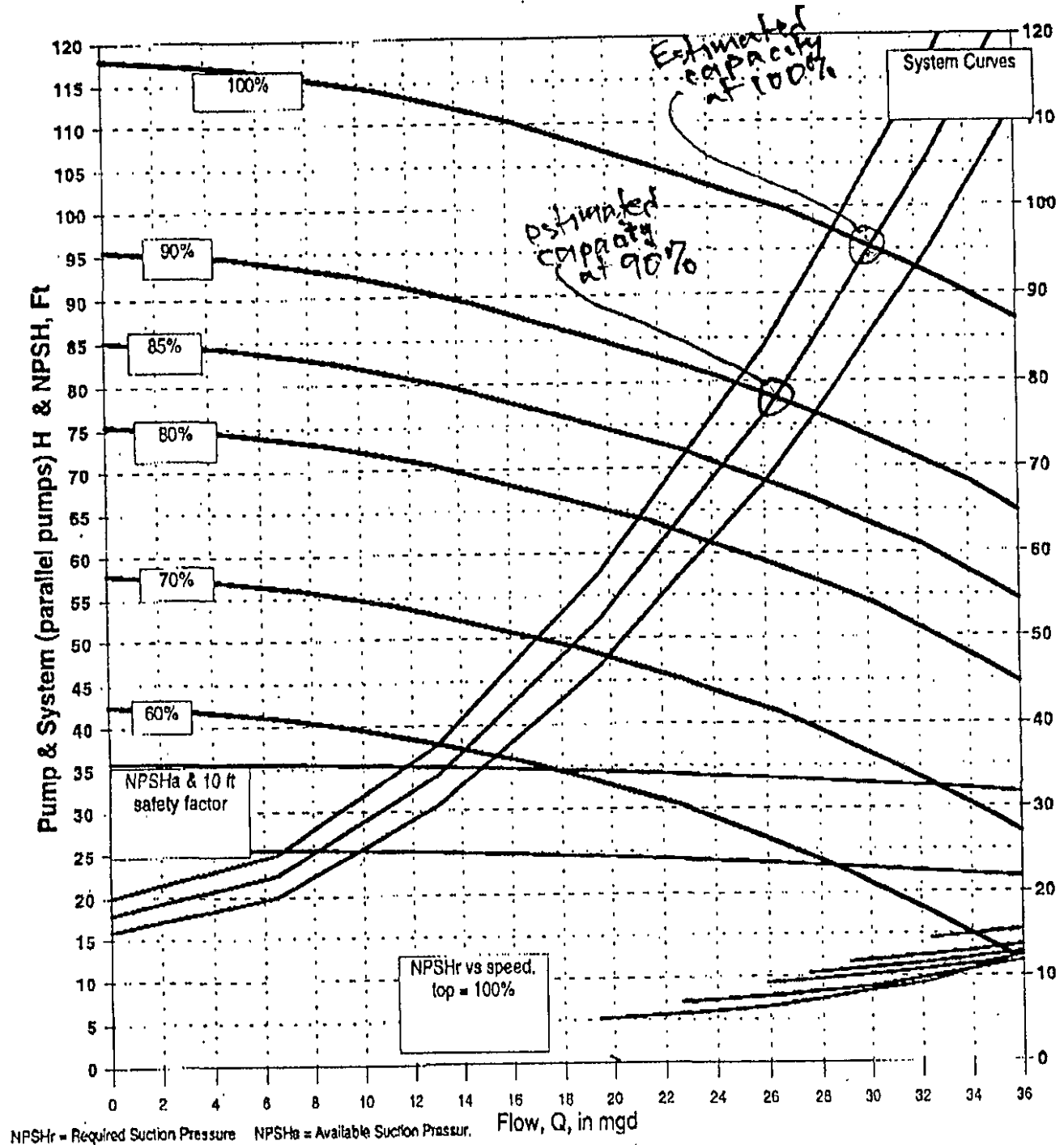
Figure 2



Modified Pump Curves = Actual pump curve less suction & disch. pipe losses; System Curve = FM line losses only.

Milpitas - Main P.S.
3 Pumps Into 36" F.M. (est. losses)

Figure 3



Mod. Pump Curves Pump NPSH >1P System Curves

Modified Pump Curves = Actual pump curve less suction & disch. pipe losses; System Curve = FM line losses only.

Appendix C

Vibration Analysis Report

**CITY OF MILPITAS
RAW SEWAGE PUMP STATION NO. 1
PUMPS 1, 4 & 5**

**VIBRATION ANALYSIS
REPORT**

BY

JAC ENGINEERING ASSOCIATES
SUNNYVALE, CA
AND
ELECTRO TEST, INC.
PLEASANTON, CA

FOR

KENNEDY/JENKS CONSULTANTS
PALO ALTO, CA

December, 2000

CITY OF MILPITAS

RAW SEWAGE PUMP STATION NO. 1

PUMPS 1, 4 & 5

Preamble

As requested by Tom Yeager of Kennedy/Jenks, on October 9, 2000, three (3) sewage pumps were operated and vibration measurements taken to determine present condition and develop signatures for future condition comparisons.

Pump No. 2 was not in place and pump No. 3 was rotating in the wrong direction.

Vibration measurement was done by Curt Hancey of Electro-Test, Inc. utilizing an SKF EMC A55 Monitor with prism 4 (Windows) program.

Measurements

The first round of measurements were taken at pump full speed conditions as follows:

MODE - Motor opposite Drive End - XY&Z
MDE - Motor Drive End - XY&Z
PDE - Pump Drive End - XY&Z
PODE - Pump Opposite Drive End - XY&Z

The subsequent rounds of measurements were taken at 70% and 50% speed. Measurements were taken during combined pumping with pumps 1 & 5 at full speed (opposite) and pumps 4 & 5 at full speed (adjacent).

Final measurements were taken with pump No. 1 at low speed with a low wet well level to determine cavitation potential from low suction head and resulting vibration levels.

Refer to page 4 Vibration Measurement Compilation for recorded levels.

Measurement Criteria and Baseline

Baseline vibration levels used for our review are from the Hydraulic Institute Standard for this type of equipment.

The H.I. Standard for acceptable levels of vibration is 0.17 IPS (inches per second) velocity.

The SKF monitor used would indicate alarm conditions at 0.10 IPS.

Readings lower than 0.01 IPS was not recorded, as we consider this an insignificant level.

For historical signature information we have provided both velocity and acceleration (envelope) plots of vibration spectra.

Velocity plots and information was used for the Vibration Measurements Compilation provided.

Review and Observations

The highest vibration level recorded as full speed normal operation was 0.1312 IPS at pump No. 4 MODE H, this is a low level, within H.I. acceptance levels. Its location indicates a possible motor bearing issue, as pump levels were very low.

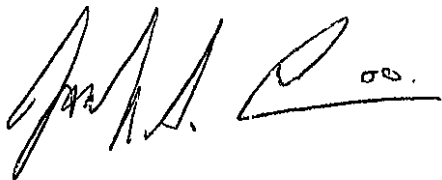
Pumps 4 & 5 increased vibration levels at PDE and PODE indicates definite influence at the suction conditions due to combination operation. Although even with the associated cavitation noise (author's observation), the level is below standard alarm point. Highest combination vibration level was 0.1172 IPS recorded at pump No. 4 PDE.

Conditions measured during this testing do not indicate any adverse operating conditions for pumps No. 1, 4 & 5.

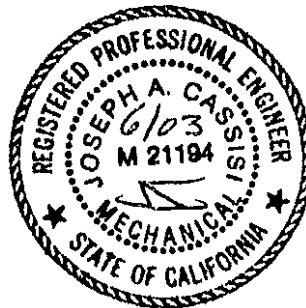
We recommend Pump No. 3 be configured for proper rotation and signature measurements be taken for future reference.

Follow-up predictive maintenance measurements should be taken in 9 to 12 months from the October measurement to compare changes. This information will dictate future maintenance.

Respectfully submitted,



Joseph A. Cassisi, P.E.



CITY OF MILPITAS RAW SEWAGE PUMP STATION NO. 1

PUMPS 1, 4 & 5 VIBRATION MEASUREMENTS COMPILATION

(Refer to Data Sheets for Frequency)

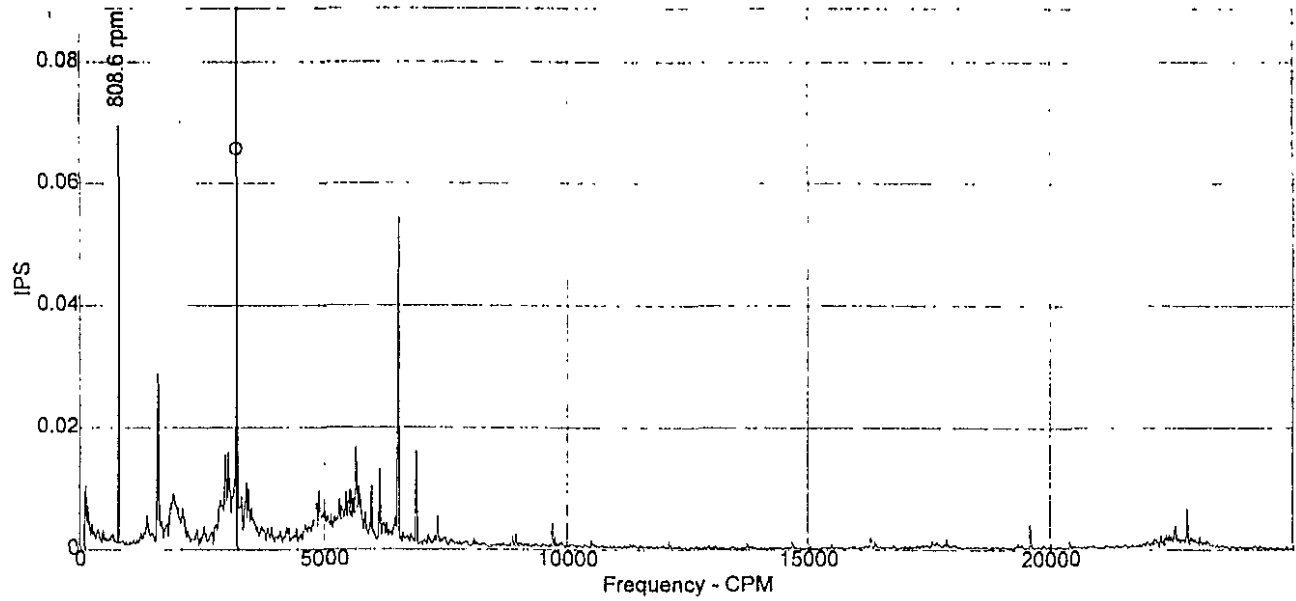
	Full Speed	70% Speed	50% Speed	Full Speed 1 & 5 Combined	Full Speed 4 & 5 Combined	Low Speed 1 Low Wet Well
	VEL (IPS)	VEL (IPS)	VEL (IPS)	VEL (IPS)	VEL (IPS)	VEL (IPS)
<u>PUMP No. 1</u>						
MODE H	0.0658	-	-	-		
MODE V	0.1069	-	-	-	N/A	N/A
MDE H	0.0431	-	-	-		
PDE H	-	-	-	0.1092		
PODE H	-	-	-	0.0669		
<u>PUMP No. 4</u>						
MODE H	0.1312	-	-	N/A	-	-
MODE V	0.1288	-	-		-	-
PDE V	0.0186	0.0199	0.0213		-	-
PDE H	-	-	-		0.1172	0.0111
PODE H	-	-	-		0.0804	-
<u>PUMP No. 5</u>						
PDE H	0.0544	0.0174	0.0451	0.0774	0.0545	0.0276
PDE V	0.0547	0.0202	0.0195	-	-	-
PDE A	-	0.0319	-	-	-	-
PODE H	-	-	-	0.0787	0.0696	0.0217

LEGEND

MODE = Motor Opposite Drive End
 MDE = Motor Drive End
 PODE = Pump Opposite Drive End
 PDE = Pump Drive End
 H = Horizontal (X)
 V = Vertical (Y)
 A = Axial (Z)
 VEL (IPS) = Velocity, Inches Per Second
 - = No Data Indicates Level Less Than 0.01

PUMP 1:MODE-ips-H

Page 1



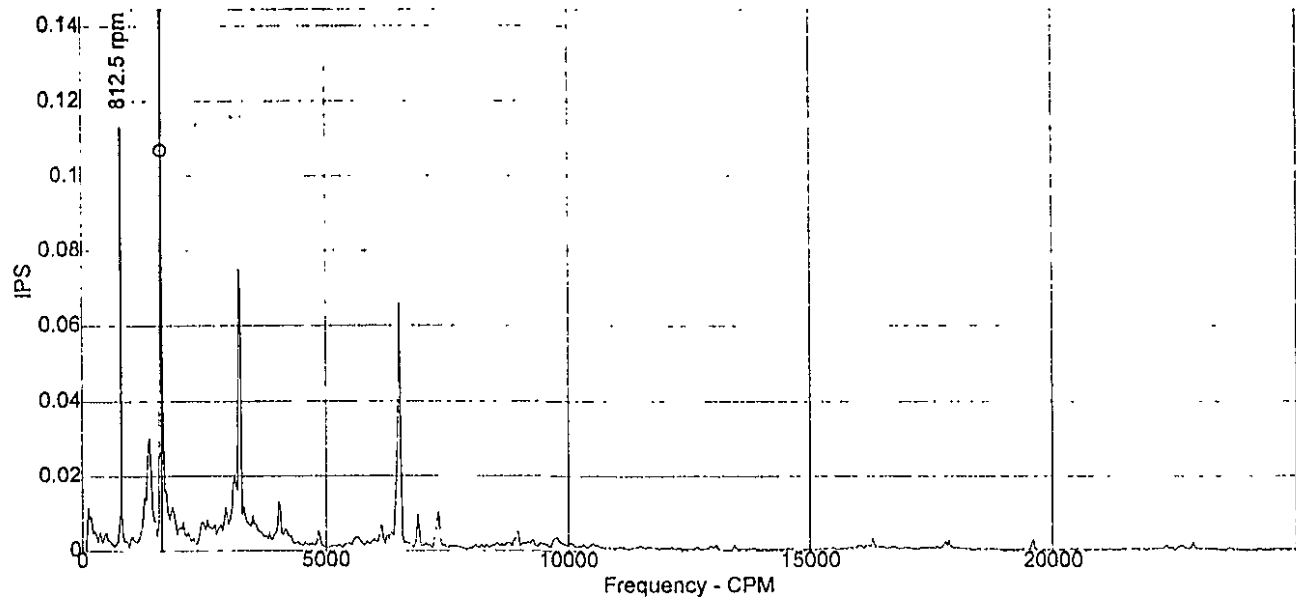
1: MODE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 09:02:19

POINT Id:MODE-ips-H Desc:@HOR Motor Opposite Drive End							
Set Id:	MILPITAS	Window:	Hanning	Speed:	808.590 RPM	Overall:	0.127
Date:	09-Oct-00 09:02:19	Lines:	1600	Threshold:	0.100000	Sync:	0.078
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.018
Detect:	Peak	Type:	FFT			NonSync:	0.099

Single Value	
CPM	3234.37
Order	4.00002
Amp	0.0657864

PUMP 1:MODE-ips-V

Page 1



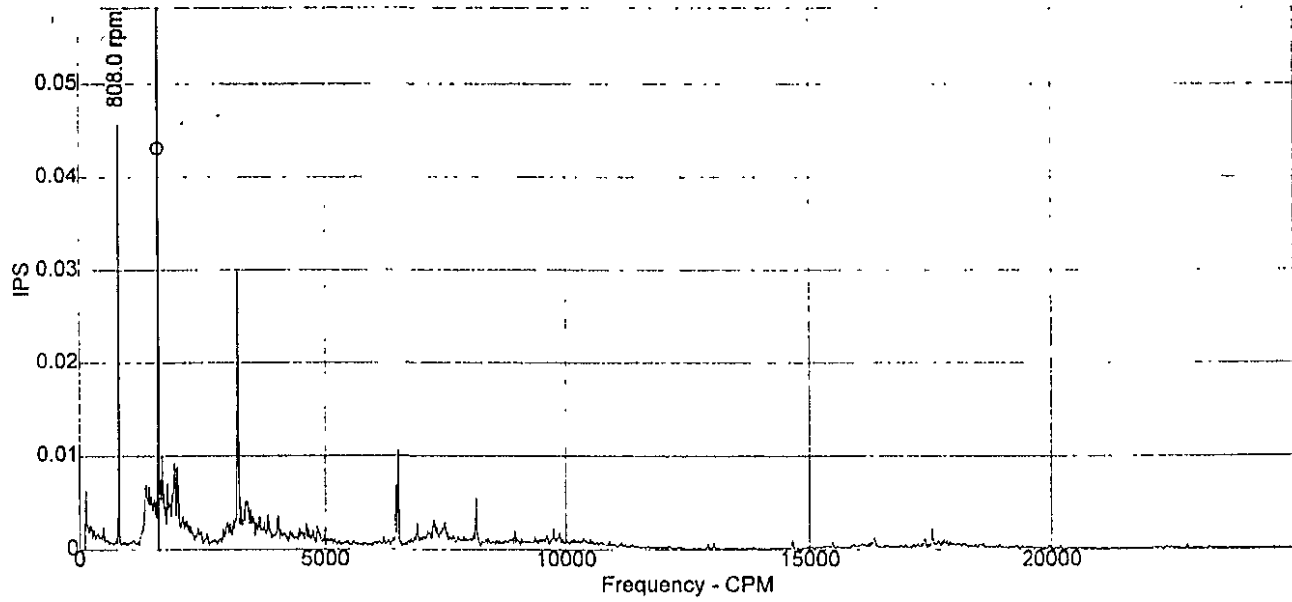
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Velocity (Acc to Vel) (Peak)
09-Oct-00 09:02:47

POINT Id:MODE-ips-V Desc:@VER Floor Reading							
Set Id:	MILPITAS	Window:	Hanning	Speed:	812.500 RPM	Overall:	0.178
Date:	09-Oct-00 09:02:47	Lines:	800	Threshold:	0.100000	Sync:	0.157
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.019
Detect:	Peak	Type:	FFT			NonSync:	0.080

Single Value	
CPM	1625
Order	2
Amp	0.106997

PUMP 1:MDE-ips-H

Page 1



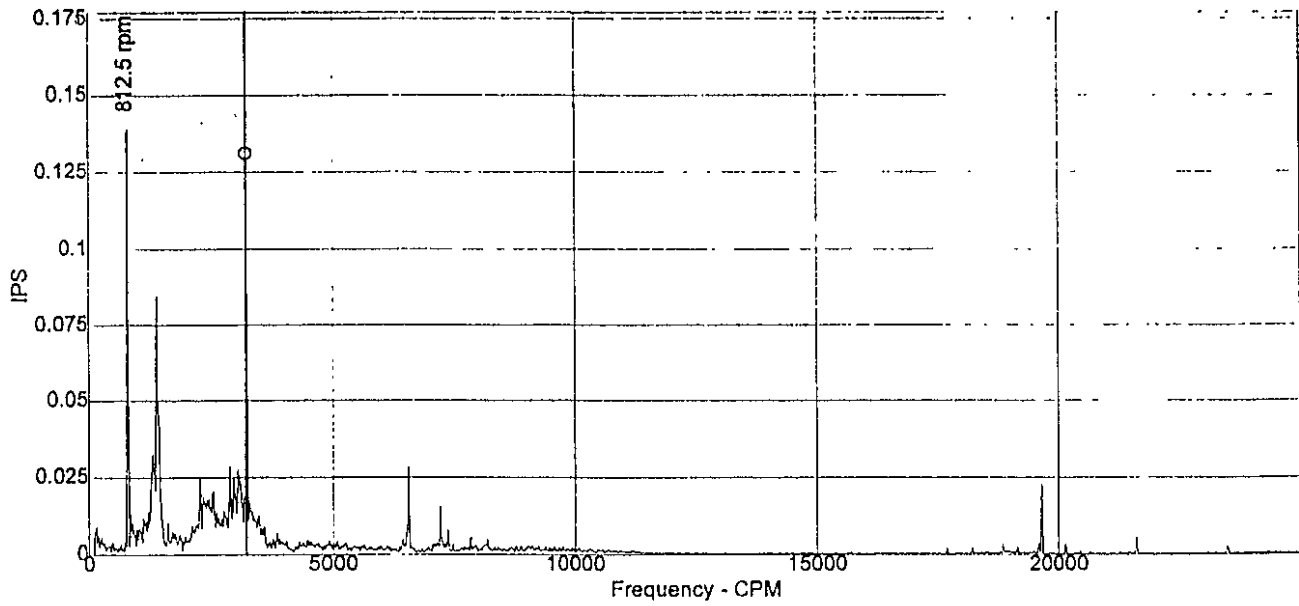
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Velocity (Acc to Vel) (Peak)
09-Oct-00 09:04:41

POINT Id:MDE-ips-H Desc:@HOR Motor Drive End							
Set Id:	MILPITAS	Window:	Hanning	Speed:	808.010 RPM	Overall:	0.073
Date:	09-Oct-00 09:04:41	Lines:	1600	Threshold:	0.100000	Sync:	0.057
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.010
Detect:	Peak	Type:	FFT			NonSync:	0.045

Single Value	
CPM	1609.37
Order	1.99178
Amp	0.0431239

PUMP 4:MODE-ips-H

Page 1



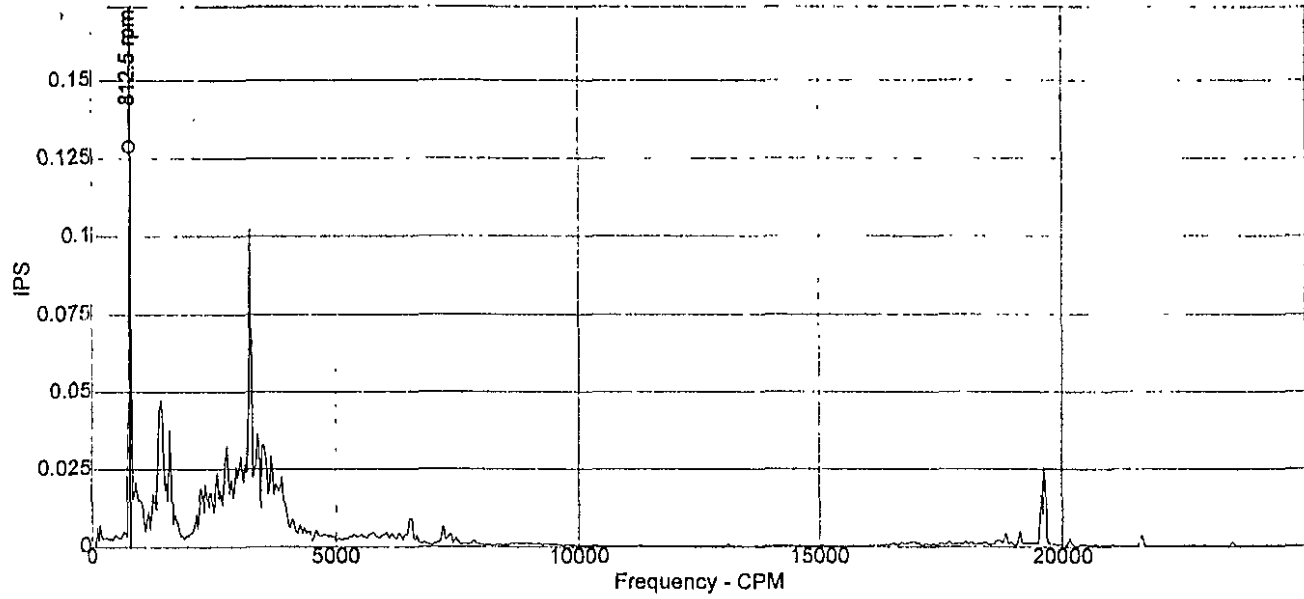
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Velocity (Acc to Vel) (Peak)
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POINT Id:MODE-ips-H Desc:@HOR Motor Opposite Drive End							
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Date:	09-Oct-00 09:23:54	Lines:	1600	Threshold:	0.100000	Sync:	0.172
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.019
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Single Value	
CPM	3250
Order	4
Amp	0.131205

PUMP 4:MODE-ips-V

Page 1



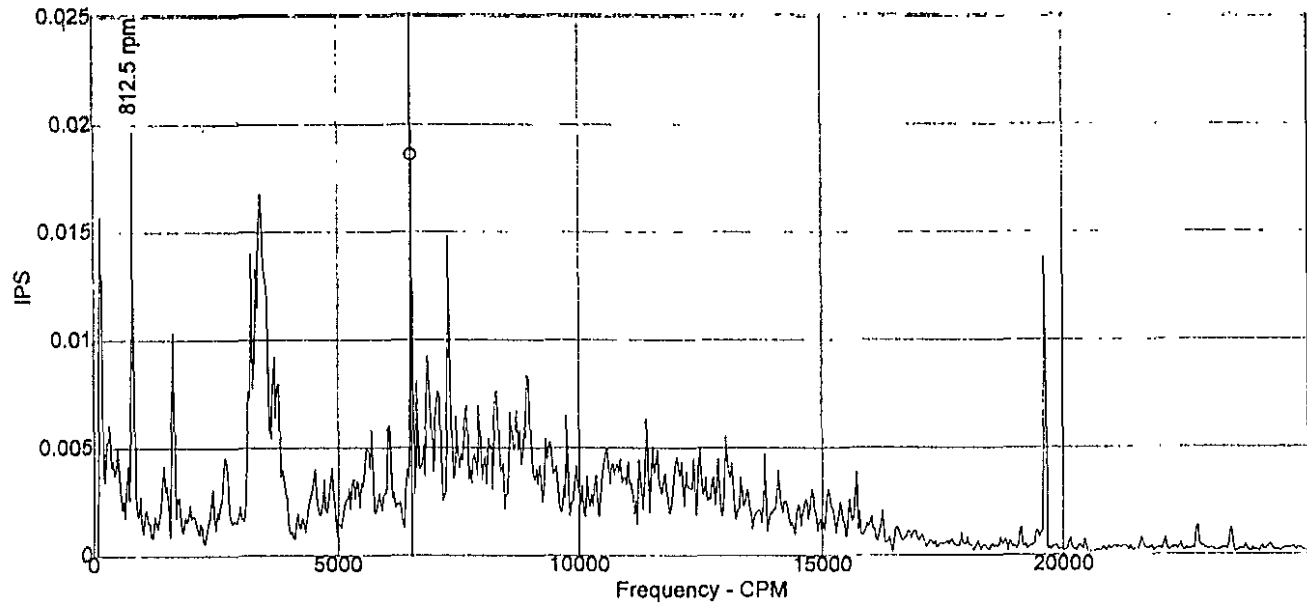
1: MODE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 09:24:28

POINT Id:MODE-ips-V Desc:@VER Motor Opposite Drive End							
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Date:	09-Oct-00 09:24:28	Lines:	800	Threshold:	0.100000	Sync:	0.175
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.014
Detect:	Peak	Type:	FFT			NonSync:	0.163

Single Value	
CPM	812.5
Order	1
Amp	0.12886

PUMP 4:PDE-ips-V

Page 1



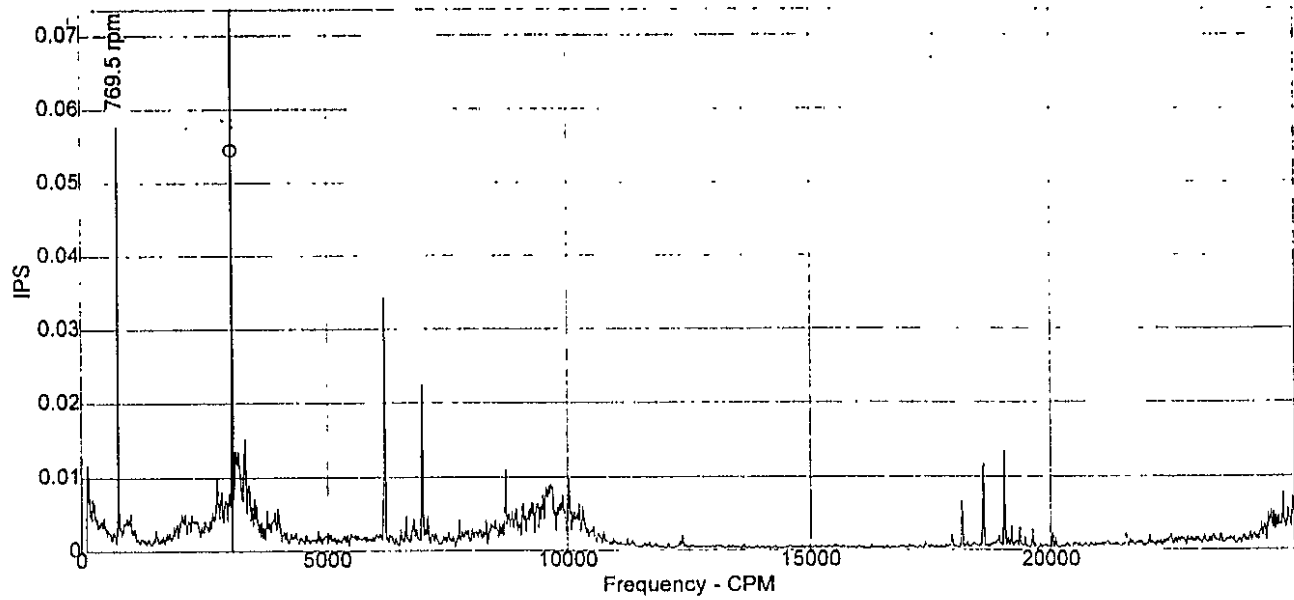
1: PDE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 09:28:48

POINT Id:PDE-ips-V Desc:@VER Pmp Drive End							
Set Id:	MILPITAS	Window:	Hanning	Speed:	812.500 RPM	Overall:	0.084
Date:	09-Oct-00 09:28:48	Lines:	800	Threshold:	0.100000	Sync:	0.039
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.023
Detect:	Peak	Type:	FFT			NonSync:	0.070

Single Value	
CPM	6531.25
Order	8.03846
Amp	0.0185981

PUMP 5:PDE-ips-H

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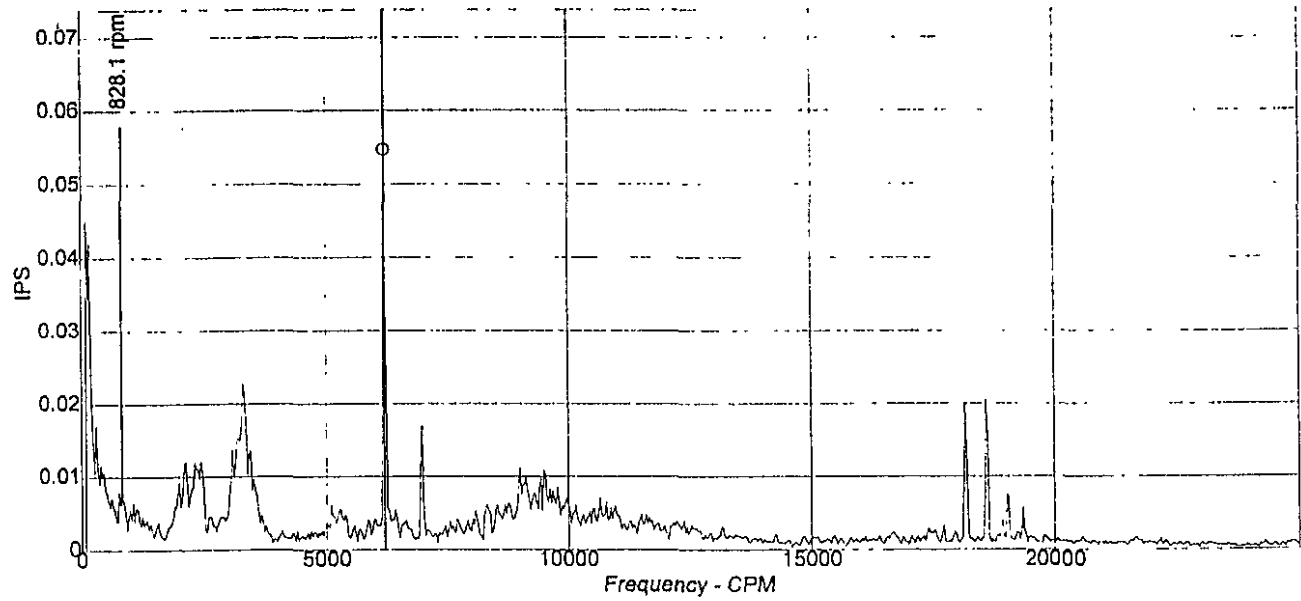
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 09:55:16

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS	Window:	Hanning	Speed:	769.530 RPM	Overall:	0.117
Date:	09-Oct-00 09:55:16	Lines:	1600	Threshold:	0.100000	Sync:	0.065
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.024
Detect:	Peak	Type:	FFT			NonSync:	0.094

Single Value	
CPM	3078.12
Order	4.00001
Amp	0.0544777

PUMP 5:PDE-ips-V

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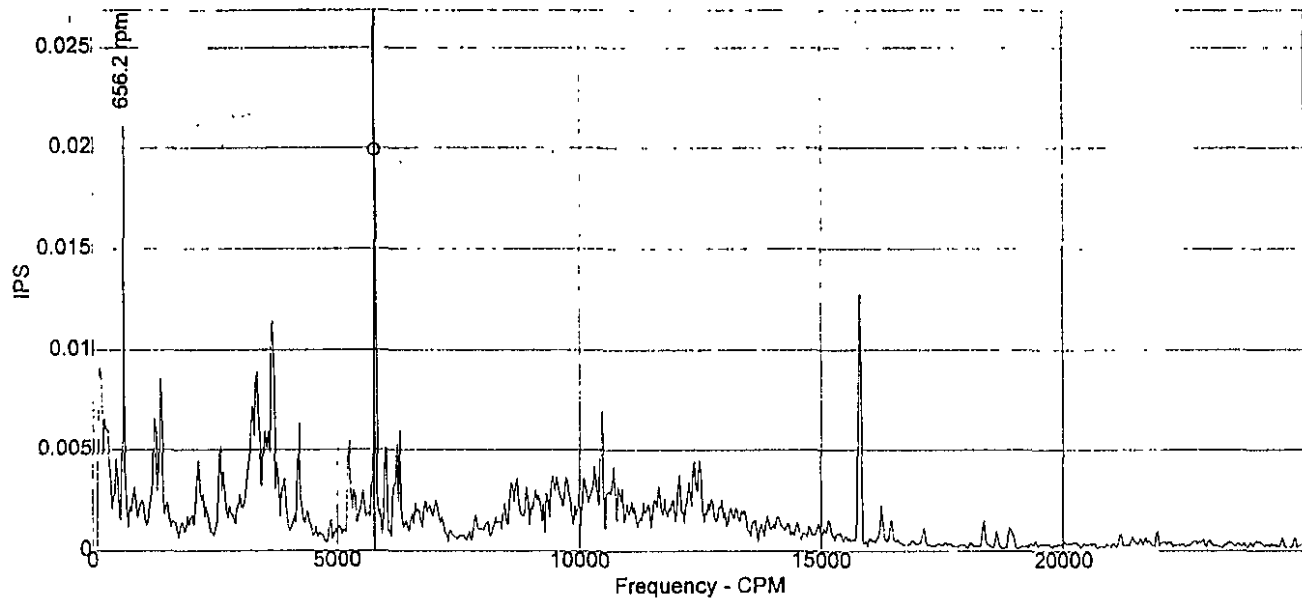
1: PDE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 09:55:52

POINT Id:PDE-ips-V Desc:@VER Pmp Drive End							
Set Id:	MILPITAS	Window:	Hanning	Speed:	828.125 RPM	Overall:	0.131
Date:	09-Oct-00 09:55:52	Lines:	800	Threshold:	0.100000	Sync:	0.041
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.068
Detect:	Peak	Type:	FFT			NonSync:	0.104

Single Value	
CPM	6187.5
Order	7.4717
Amp	0.0547284

PUMP 4:PDE-ips-V

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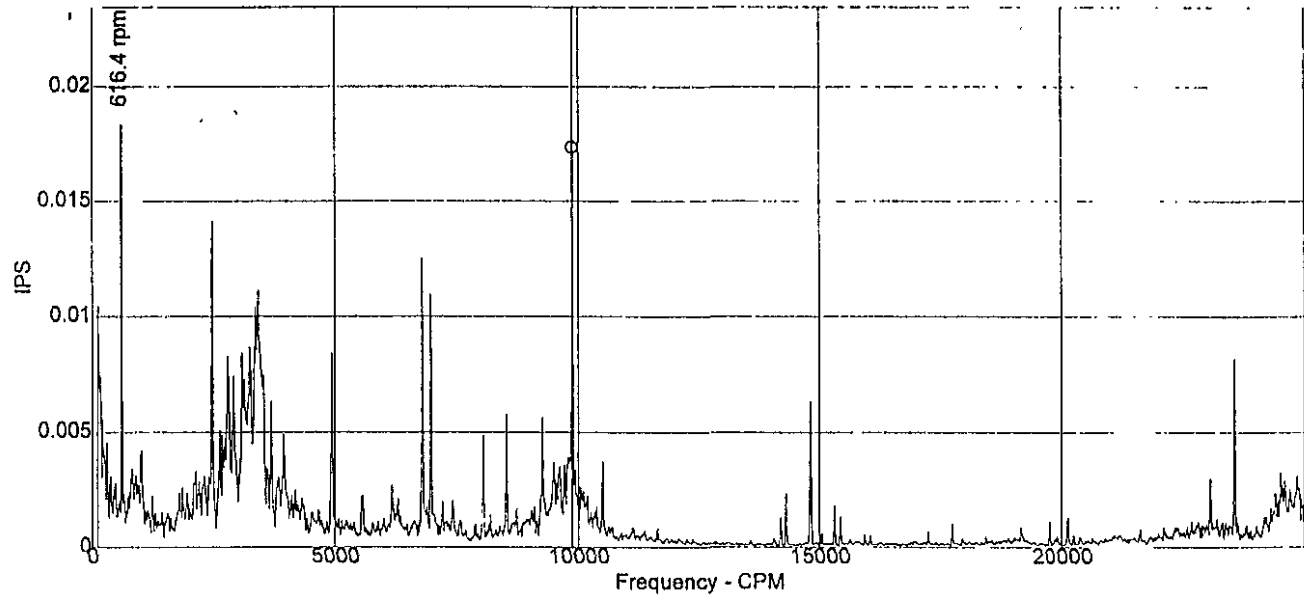
T: PDE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 11:33:51

POINT Id:PDE-ips-V Desc:@VER Pmp Drive End							
Set Id:	MILPITAS 2	Window:	Hanning	Speed:	656.250 RPM	Overall:	0.057
Date:	09-Oct-00 11:33:51	Lines:	800	Threshold:	0.100000	Sync:	0.025
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.017
Detect:	Peak	Type:	FFT			NonSync:	0.048

Single Value	
CPM	5781.25
Order	8.80952
Amp	0.0199148

PUMP 5:PDE-ips-H

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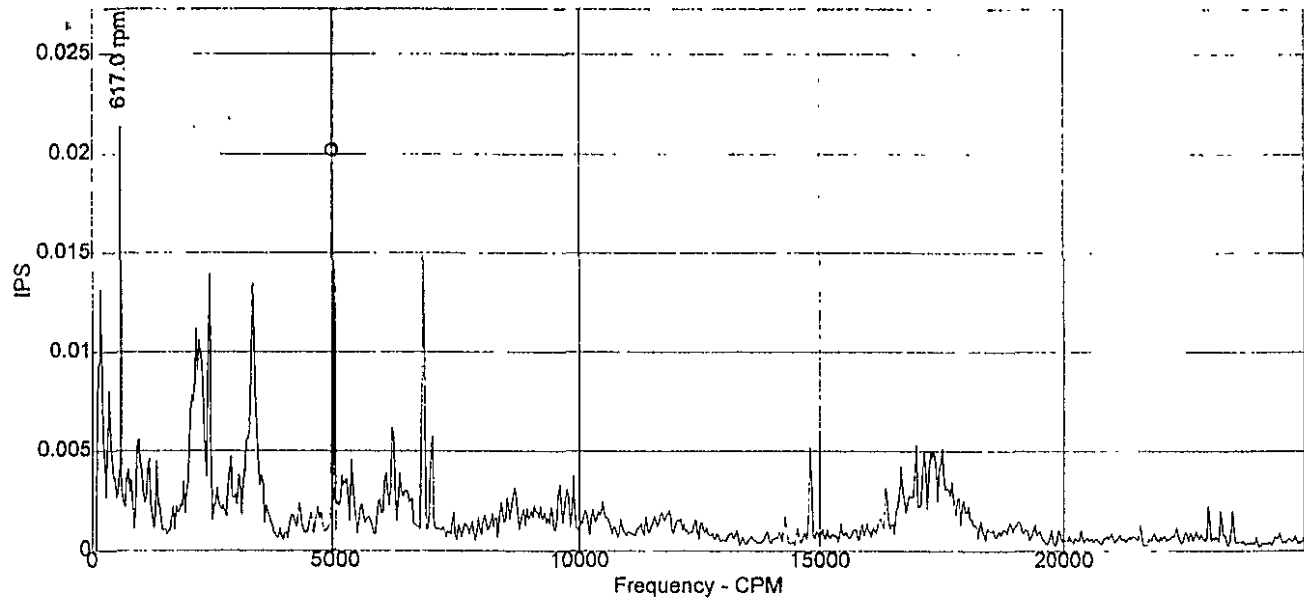
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 11:40:05

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 2	Window:	Hanning	Speed:	616.360 RPM	Overall:	0.067
Date:	09-Oct-00 11:40:05	Lines:	1600	Threshold:	0.100000	Sync:	0.035
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.019
Detect:	Peak	Type:	FFT			NonSync:	0.054

Single Value	
CPM	9875
Order	16.0215
Amp	0.0173758

PUMP 5:PDE-ips-V

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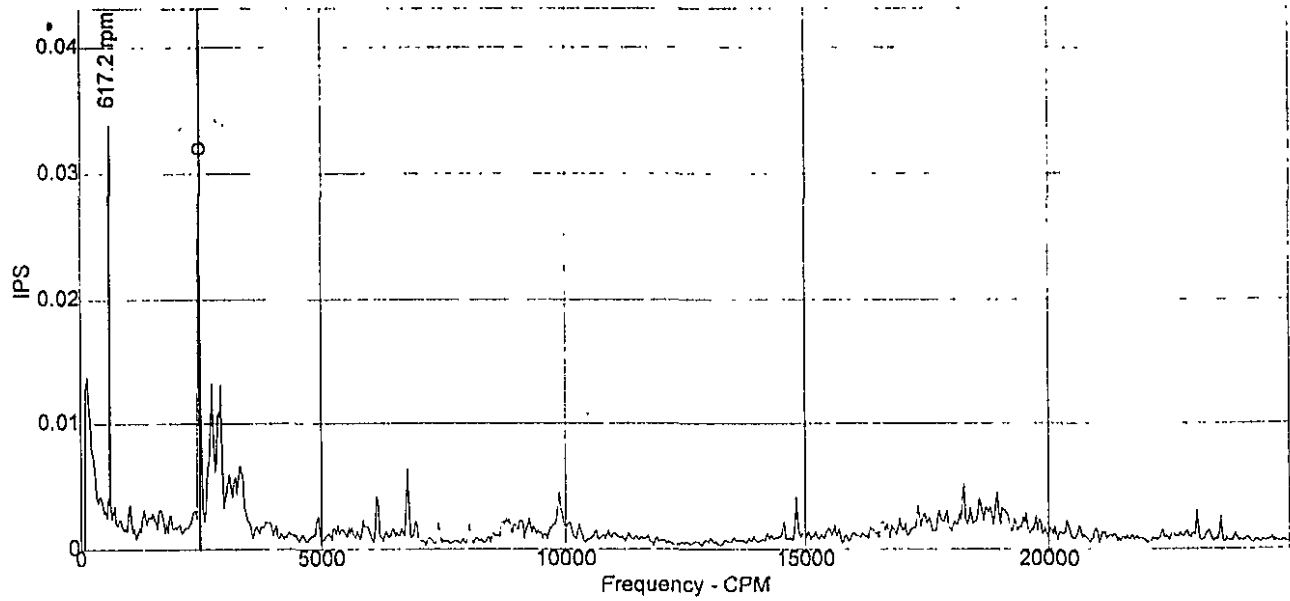
1: PDE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 11:40:41

POINT Id:PDE-ips-V Desc:@VER Pmp Drive End							
Set Id:	MILPITAS 2	Window:	Hanning	Speed:	617.000 RPM	Overall:	0.062
Date:	09-Oct-00 11:40:41	Lines:	800	Threshold:	0.100000	Sync:	0.035
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.021
Detect:	Peak	Type:	FFT			NonSync:	0.047

Single Value	
CPM	4937.5
Order	8.00243
Amp	0.0202137

PUMP 5:PDE-ips-A

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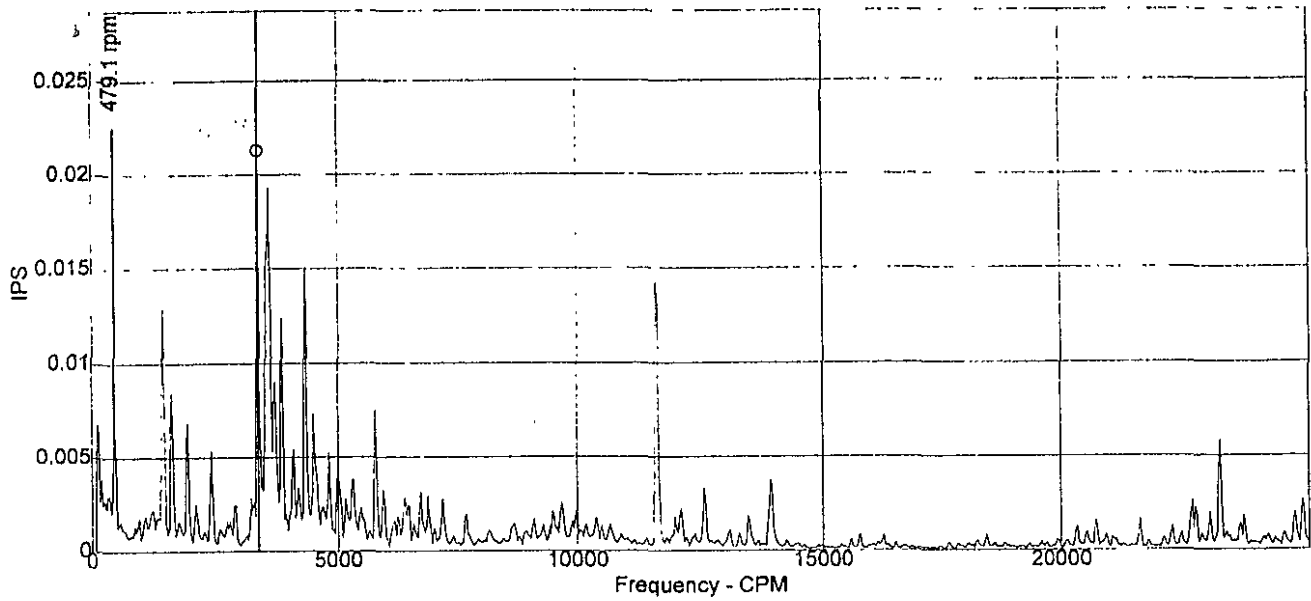
1: PDE-ips-A
Velocity (Acc to Vel) (Peak)
09-Oct-00 11:41:12

POINT Id:PDE-ips-A Desc:@AXL Pmp Drive End						
Set Id:	MILPITAS 2	Window:	Hanning	Speed:	617.175 RPM	Overall: 0.062
Date:	09-Oct-00 11:41:12	Lines:	800	Threshold:	0.100000	Sync: 0.039
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync: 0.024
Detect:	Peak	Type:	FFT			NonSync: 0.042

Single Value	
CPM	2468.75
Order	4.00008
Amp	0.0319864

PUMP 4:PDE-ips-V

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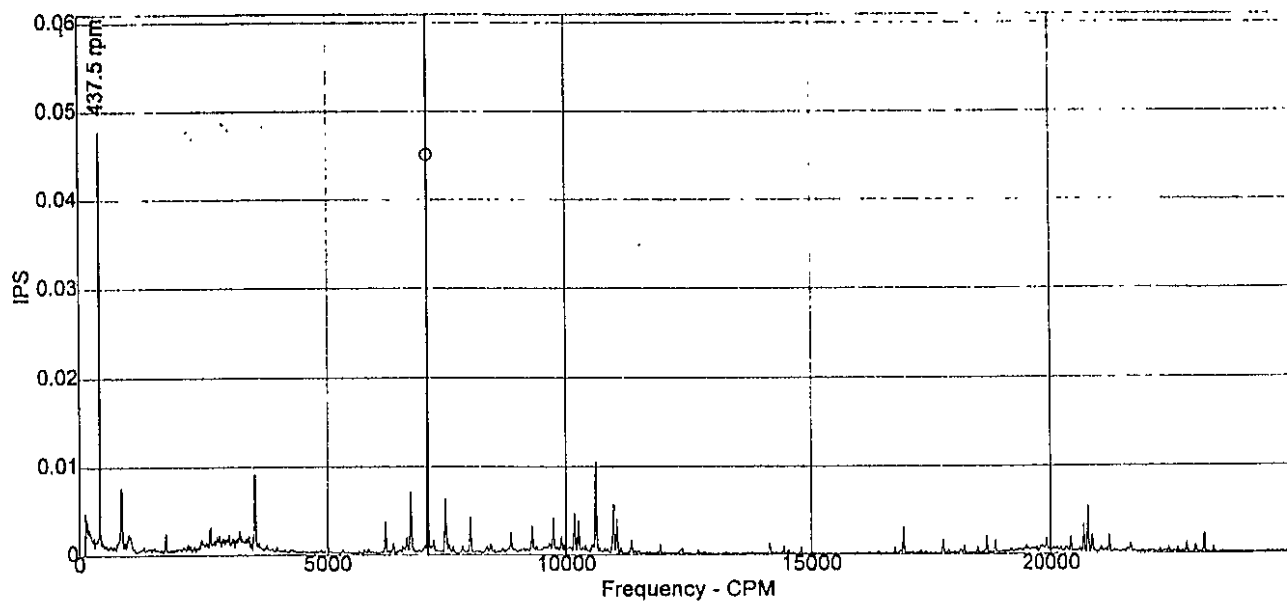
1: PDE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:11:31

POINT Id:PDE-ips-V Desc:@VER Pmp Drive End							
Set Id:	MILPITAS 3	Window:	Hanning	Speed:	479.150 RPM	Overall:	0.057
Date:	09-Oct-00 14:11:31	Lines:	800	Threshold:	0.100000	Sync:	0.037
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.010
Detect:	Peak	Type:	FFT			NonSync:	0.043

Single Value	
CPM	3375
Order	7.04372
Amp	0.0212911

PUMP 5:PDE-ips-H

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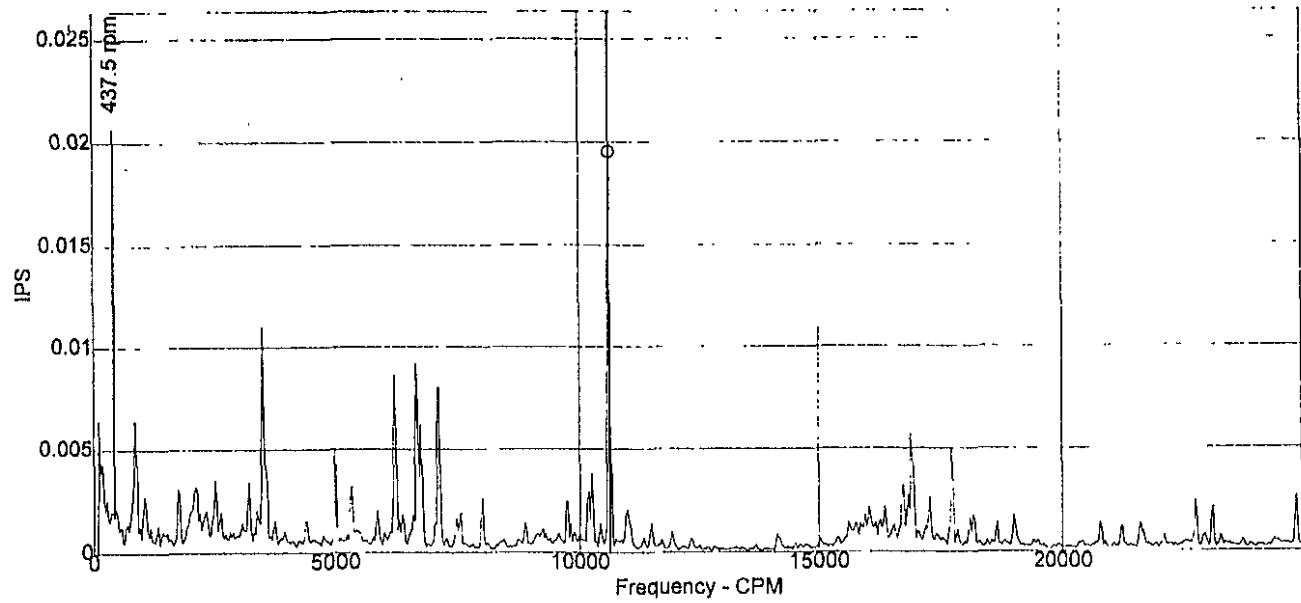
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:17:50

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 3	Window:	Hanning	Speed:	437.500 RPM	Overall:	0.057
Date:	09-Oct-00 14:17:50	Lines:	1600	Threshold:	0.100000	Sync:	0.013
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.009
Detect:	Peak	Type:	FFT			NonSync:	0.055

Single Value	
CPM	7078.12
Order	16.1786
Amp	0.0451461

PUMP 5:PDE-ips-V

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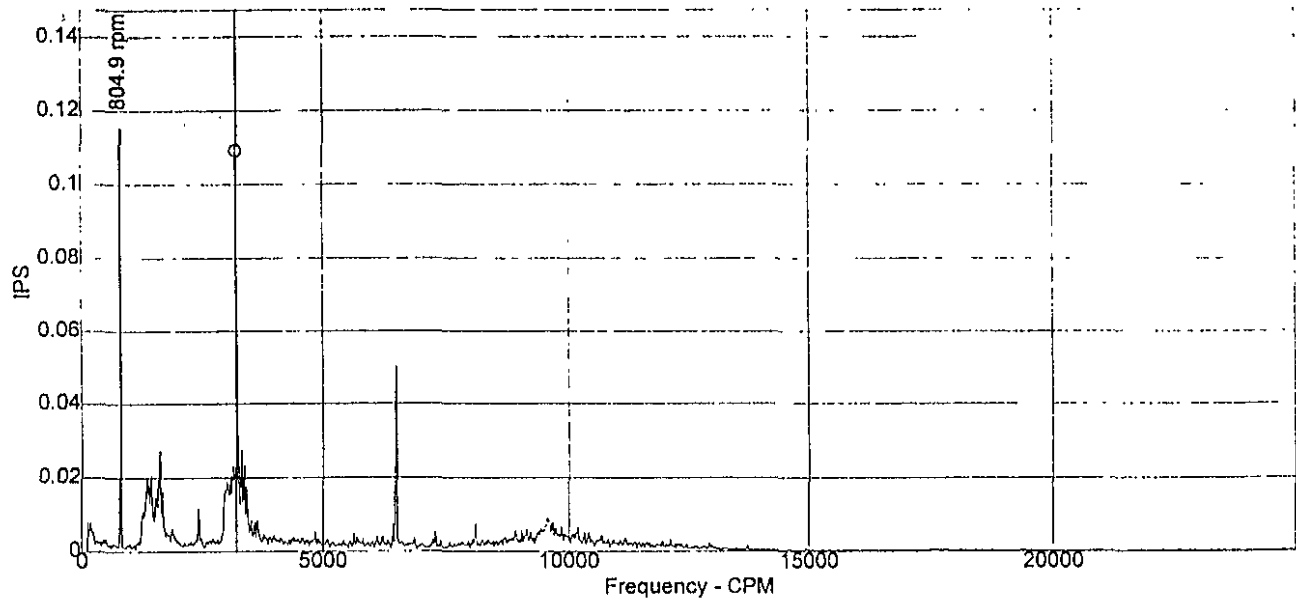
1: PDE-ips-V
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:18:22

POINT Id:PDE-ips-V Desc:@VER Pmp Drive End							
Set Id:	MILPITAS 3	Window:	Hanning	Speed:	437.500 RPM	Overall:	0.039
Date:	09-Oct-00 14:18:22	Lines:	800	Threshold:	0.100000	Sync:	0.016
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.008
Detect:	Peak	Type:	FFT			NonSync:	0.035

Single Value	
CPM	10625
Order	24.2857
Amp	0.0195372

PUMP 1:PDE-ips-H

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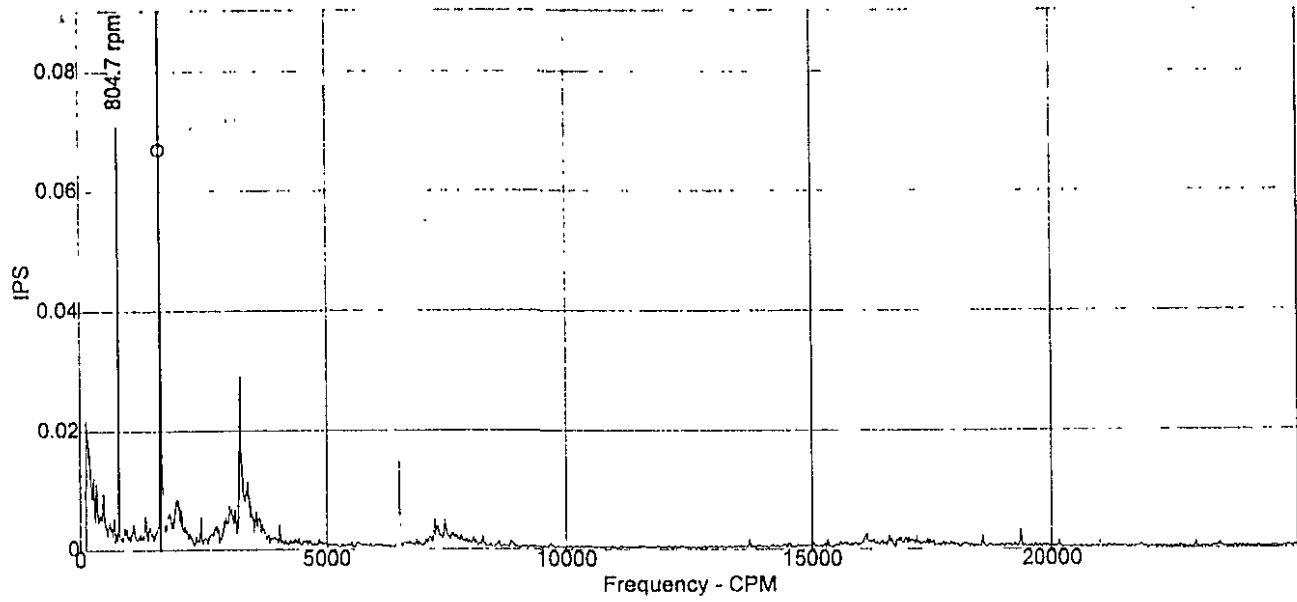
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:47:10

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 4	Window:	Hanning	Speed:	804.900 RPM	Overall:	0.190
Date:	09-Oct-00 14:47:10	Lines:	1600	Threshold:	0.100000	Sync:	0.136
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.018
Detect:	Peak	Type:	FFT			NonSync:	0.131

Single Value	
CPM	3218.75
Order	3.99894
Amp	0.109253

PUMP 1:PODE-ips-H

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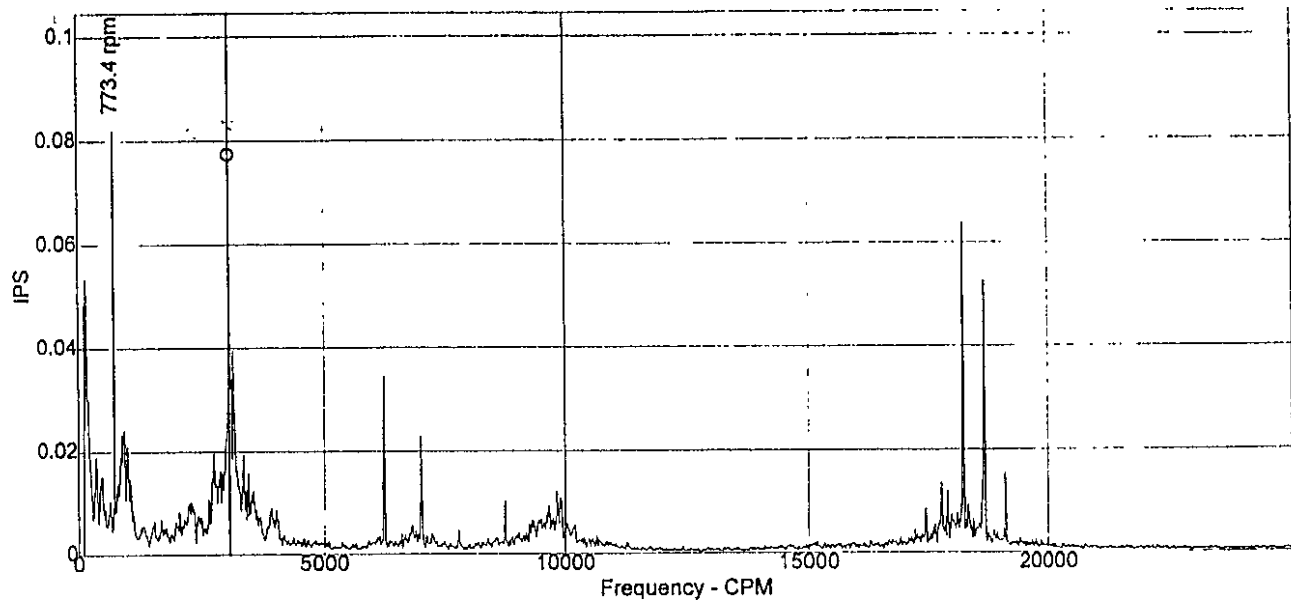
1: PODE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:47:42

POINT Id:PODE-ips-H Desc:@HOR Pmp Opposite Drive End							
Set Id:	MILPITAS 4	Window:	Hanning	Speed:	804.685 RPM	Overall:	0.111
Date:	09-Oct-00 14:47:42	Lines:	1600	Threshold:	0.100000	Sync:	0.080
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.047
Detect:	Peak	Type:	FFT			NonSync:	0.061

Single Value	
CPM	1609.37
Order	2.00001
Amp	0.0669237

PUMP 5:PDE-ips-H

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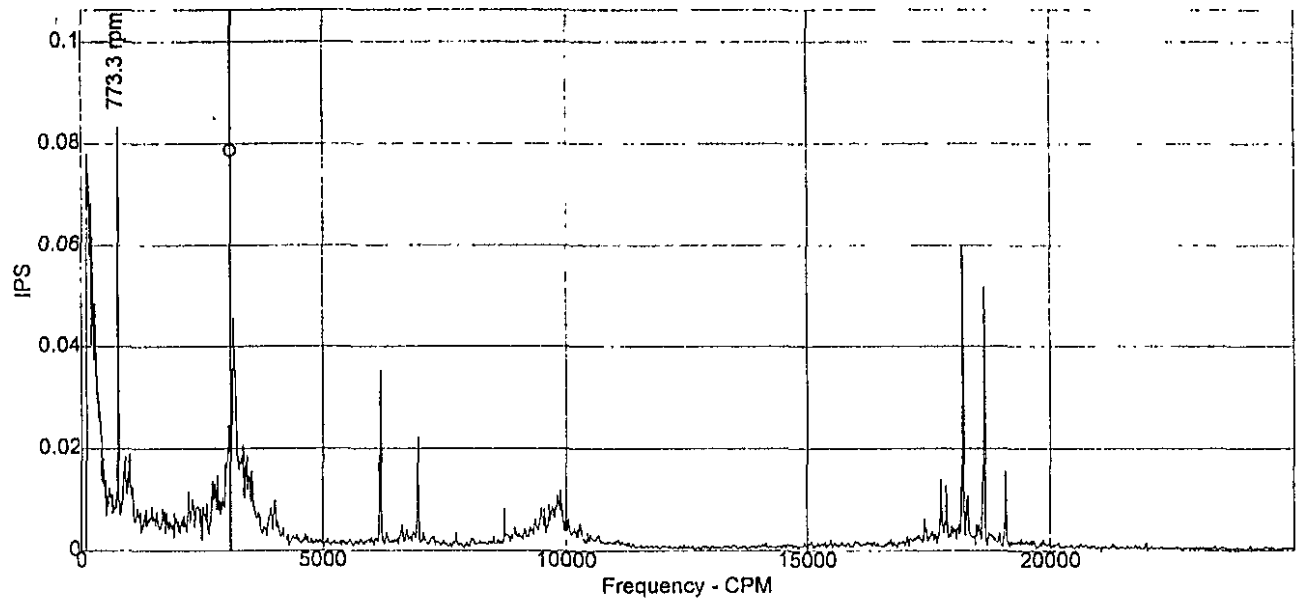
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:48:52

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 4	Window:	Hanning	Speed:	773.400 RPM	Overall:	0.224
Date:	09-Oct-00 14:48:52	Lines:	1600	Threshold:	0.100000	Sync:	0.090
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.101
Detect:	Peak	Type:	FFT			NonSync:	0.178

Single Value	
CPM	3093.75
Order	4.00019
Amp	0.0774582

PUMP 5:PODE-ips-H

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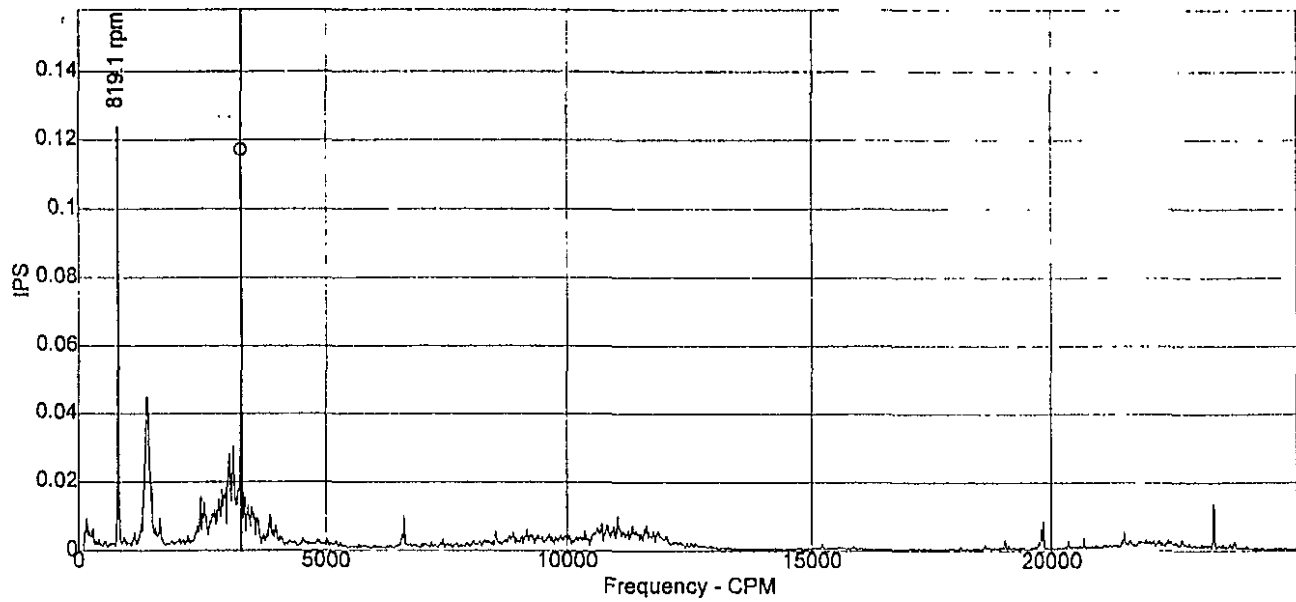
1: PODE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:49:19

POINT Id:PODE-ips-H Desc:@HOR Pmp Opposite Drive End							
Set Id:	MILPITAS 4	Window:	Hanning	Speed:	773.323 RPM	Overall:	0.271
Date:	09-Oct-00 14:49:19	Lines:	1600	Threshold:	0.100000	Sync:	0.092
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.187
Detect:	Peak	Type:	FFT			NonSync:	0.174

Single Value	
CPM	3093.75
Order	4.00059
Amp	0.0787617

PUMP 4:PDE-ips-H

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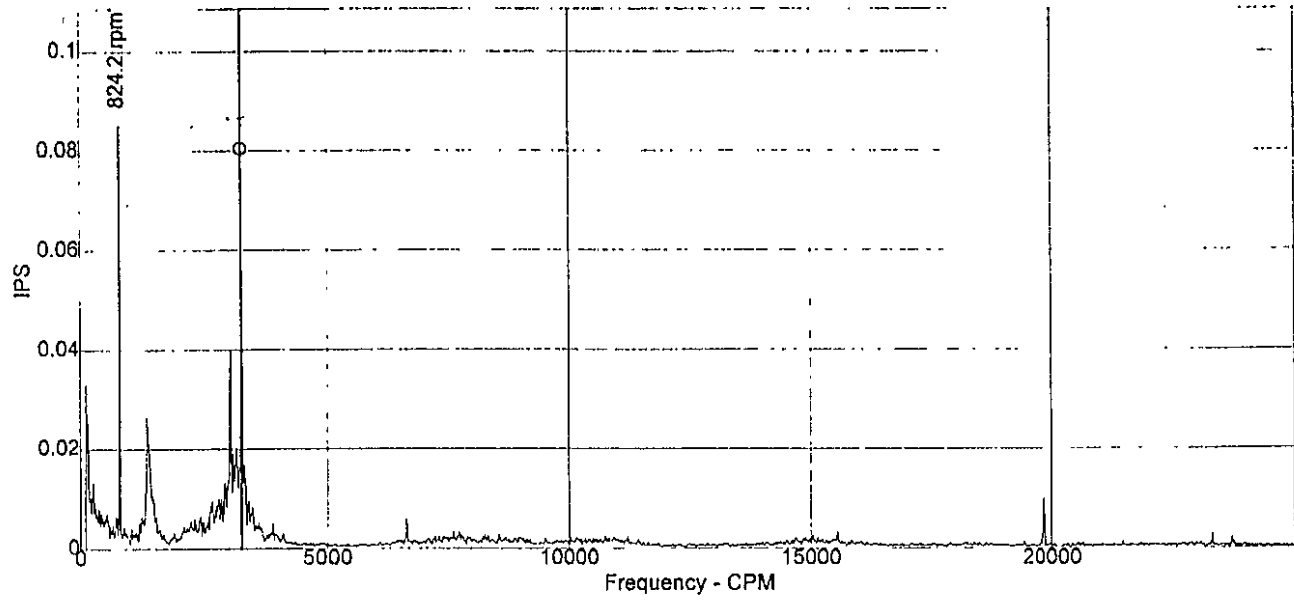
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 15:31:10

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 5	Window:	Hanning	Speed:	819.096 RPM	Overall:	0.207
Date:	09-Oct-00 15:31:10	Lines:	1600	Threshold:	0.100000	Sync:	0.143
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.019
Detect:	Peak	Type:	FFT			NonSync:	0.149

Single Value	
CPM	3281.25
Order	4.00594
Amp	0.117283

PUMP 4:PODE-ips-H

Page 1



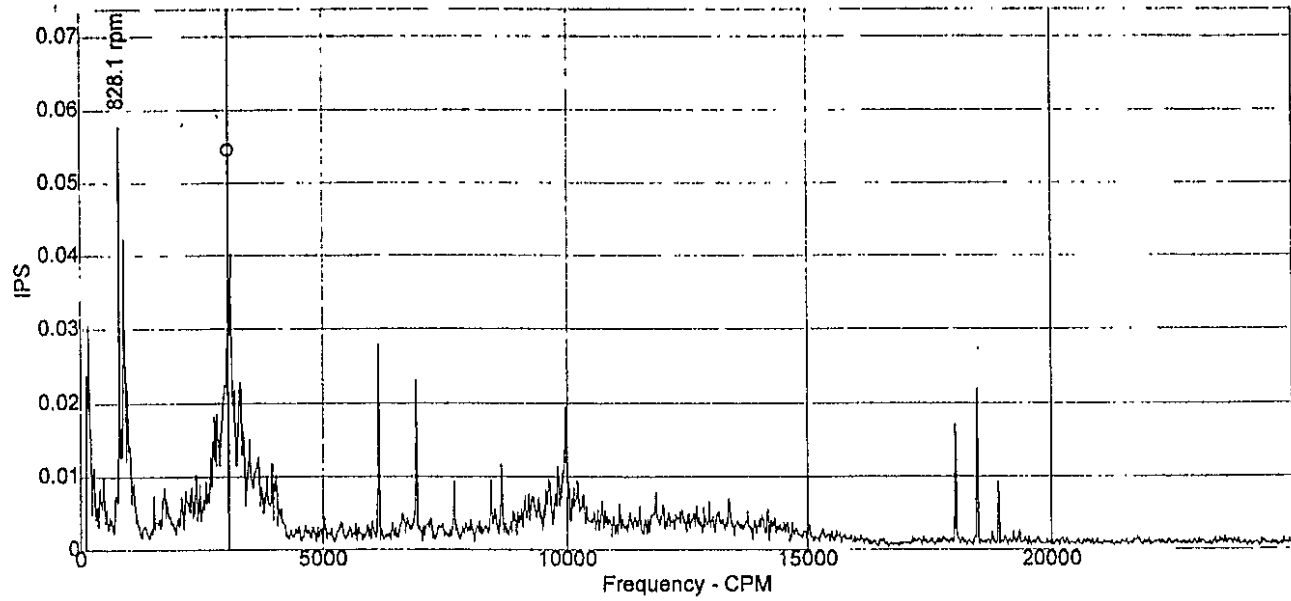
1: PODE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 15:31:43

POINT Id:PODE-ips-H Desc:@HOR Pmp Opposite Drive End							
Set Id:	MILPITAS 5	Window:	Hanning	Speed:	824.218 RPM	Overall:	0.142
Date:	09-Oct-00 15:31:43	Lines:	1600	Threshold:	0.100000	Sync:	0.084
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.052
Detect:	Peak	Type:	FFT			NonSync:	0.102

Single Value	
CPM	3281.25
Order	3.98105
Amp	0.0804475

PUMP 5:PDE-ips-H

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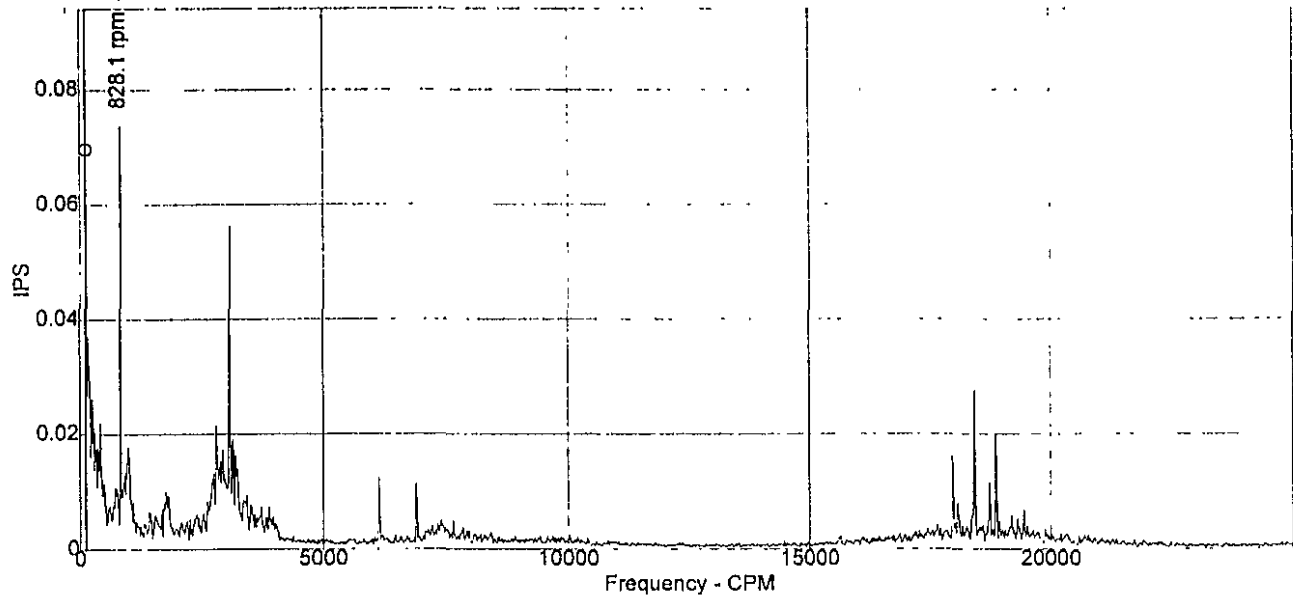
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 15:32:24

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 5	Window:	Hanning	Speed:	828.125 RPM	Overall:	0.195
Date:	09-Oct-00 15:32:24	Lines:	1600	Threshold:	0.100000	Sync:	0.047
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.056
Detect:	Peak	Type:	FFT			NonSync:	0.180

Single Value	
CPM	3062.5
Order	3.69811
Amp	0.0545842

PUMP 5:PODE-ips-H

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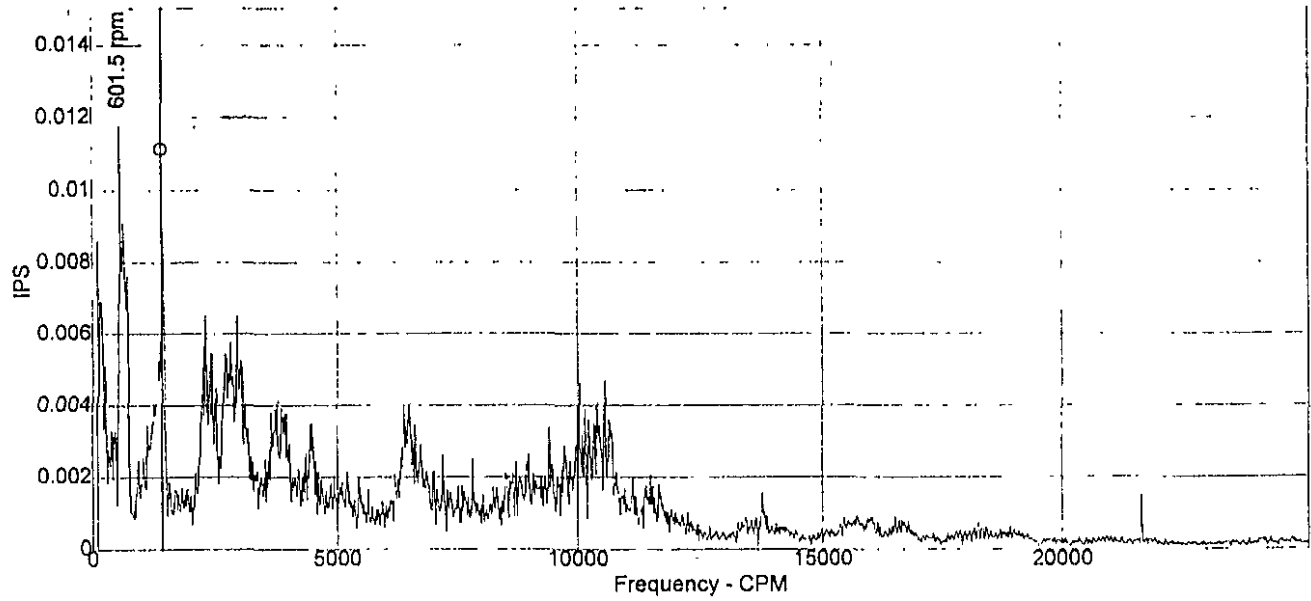
1: PODE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 15:32:57

POINT Id:PODE-ips-H Desc:@HOR Pmp Opposite Drive End							
Set Id:	MILPITAS 5	Window:	Hanning	Speed:	828.125 RPM	Overall:	0.169
Date:	09-Oct-00 15:32:57	Lines:	1600	Threshold:	0.100000	Sync:	0.022
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.109
Detect:	Peak	Type:	FFT			NonSync:	0.126

Single Value	
CPM	125
Order	0.150943
Amp	0.0696748

PUMP 4.1:PDE-ips-H

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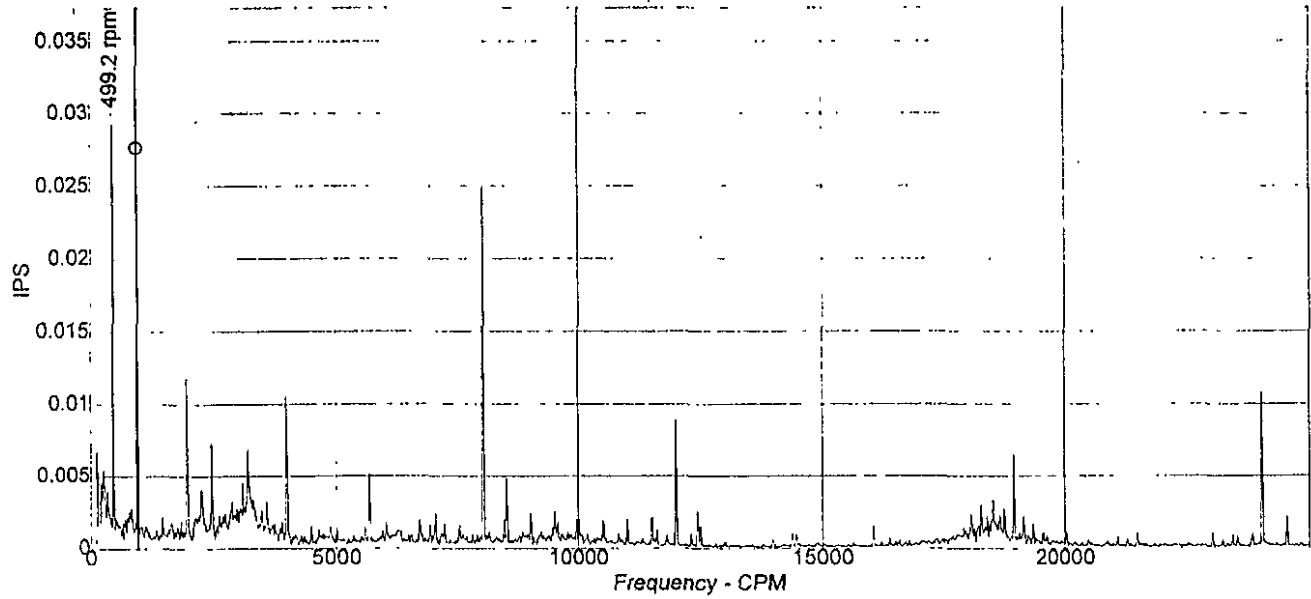
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 15:54:34

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 5	Window:	Hanning	Speed:	601.500 RPM	Overall:	0.061
Date:	09-Oct-00 15:54:34	Lines:	1600	Threshold:	0.100000	Sync:	0.019
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.019
Detect:	Peak	Type:	FFT			NonSync:	0.054

Single Value	
CPM	1421.87
Order	2.36388
Amp	0.0111337

PUMP 5.1:PDE-ips-H

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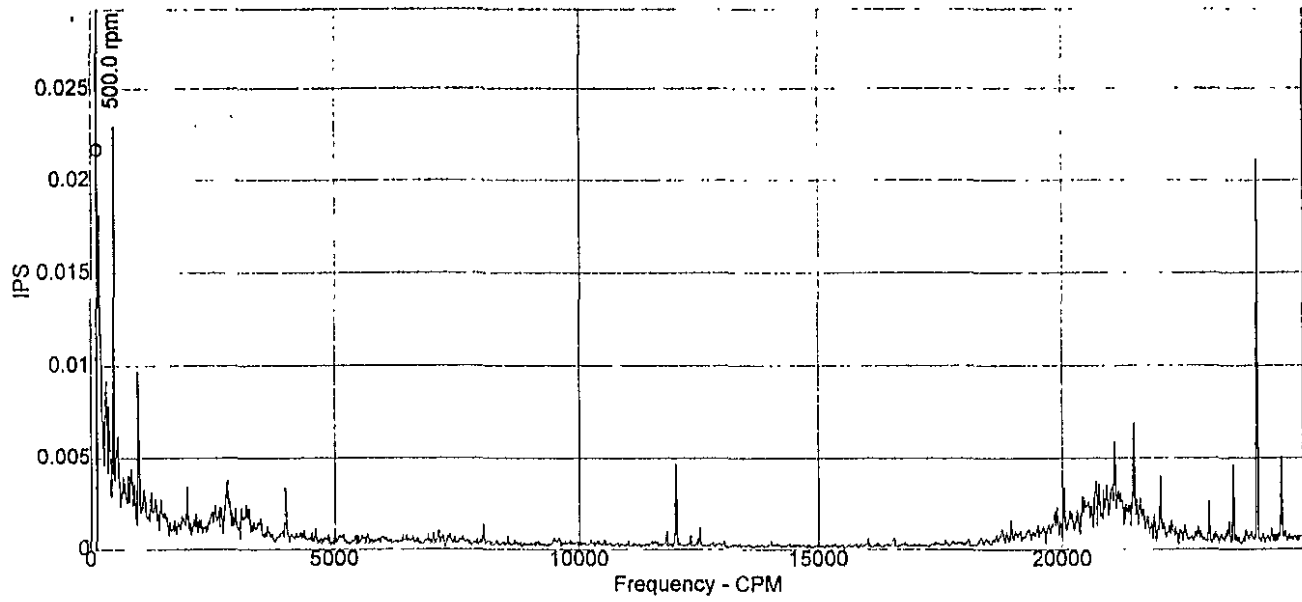
1: PDE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:58:03

POINT Id:PDE-ips-H Desc:@HOR Pmp Drive End							
Set Id:	MILPITAS 4	Window:	Hanning	Speed:	499.213 RPM	Overall:	0.056
Date:	09-Oct-00 14:58:03	Lines:	1600	Threshold:	0.100000	Sync:	0.041
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.015
Detect:	Peak	Type:	FFT			NonSync:	0.035

Single Value	
CPM	1000
Order	2.00315
Amp	0.0276561

PUMP 5.1:PODE-ips-H

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1: PODE-ips-H
Velocity (Acc to Vel) (Peak)
09-Oct-00 14:58:35

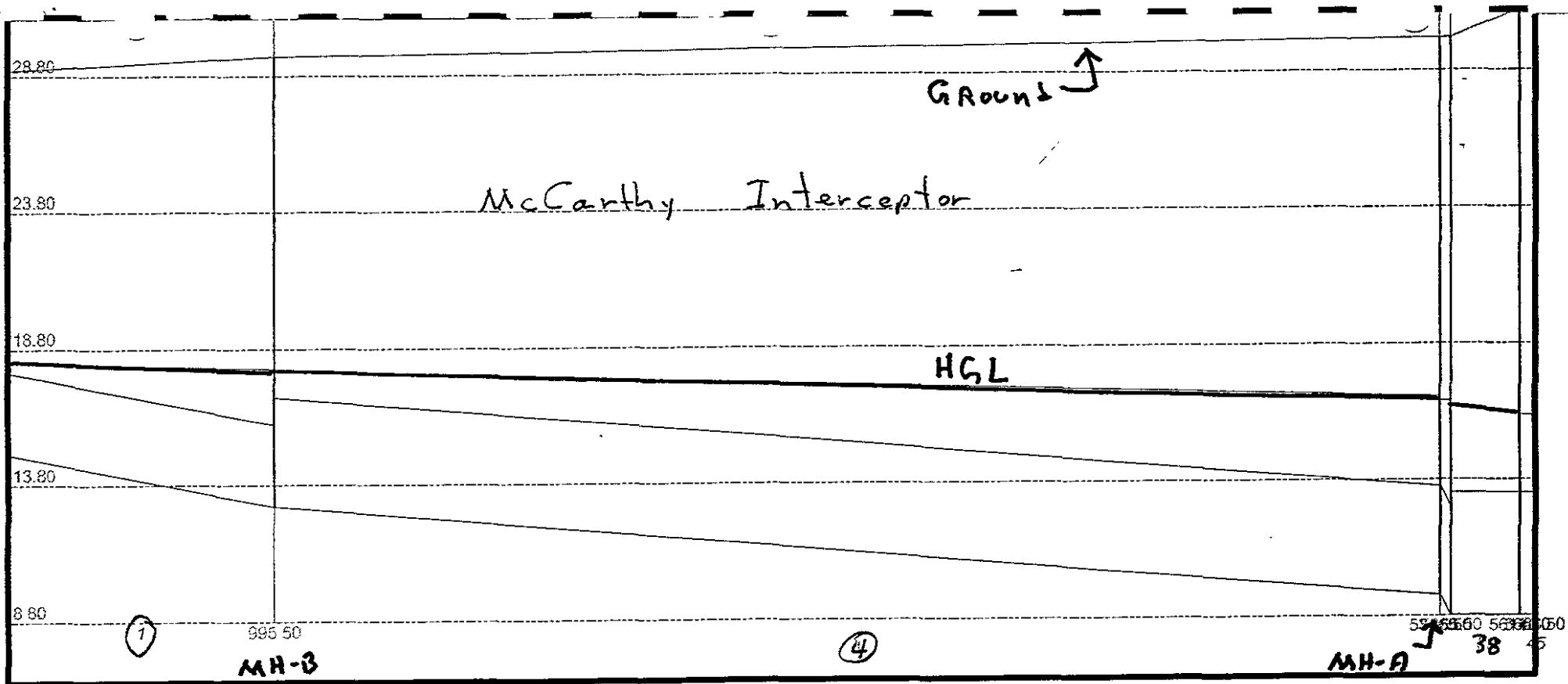
POINT Id:PODE-ips-H Desc:@HOR Pmp Opposite Drive End							
Set Id:	MILPITAS 4	Window:	Hanning	Speed:	500.000 RPM	Overall:	0.063
Date:	09-Oct-00 14:58:35	Lines:	1600	Threshold:	0.100000	Sync:	0.020
Freq:	0.0 - 25000.0 CPM	Aver:	4	Units:	IPS	SubSync:	0.043
Detect:	Peak	Type:	FFT			NonSync:	0.040

Single Value	
CPM	140.625
Order	0.28125
Amp	0.0217334

Appendix D

Computer Modeling Results

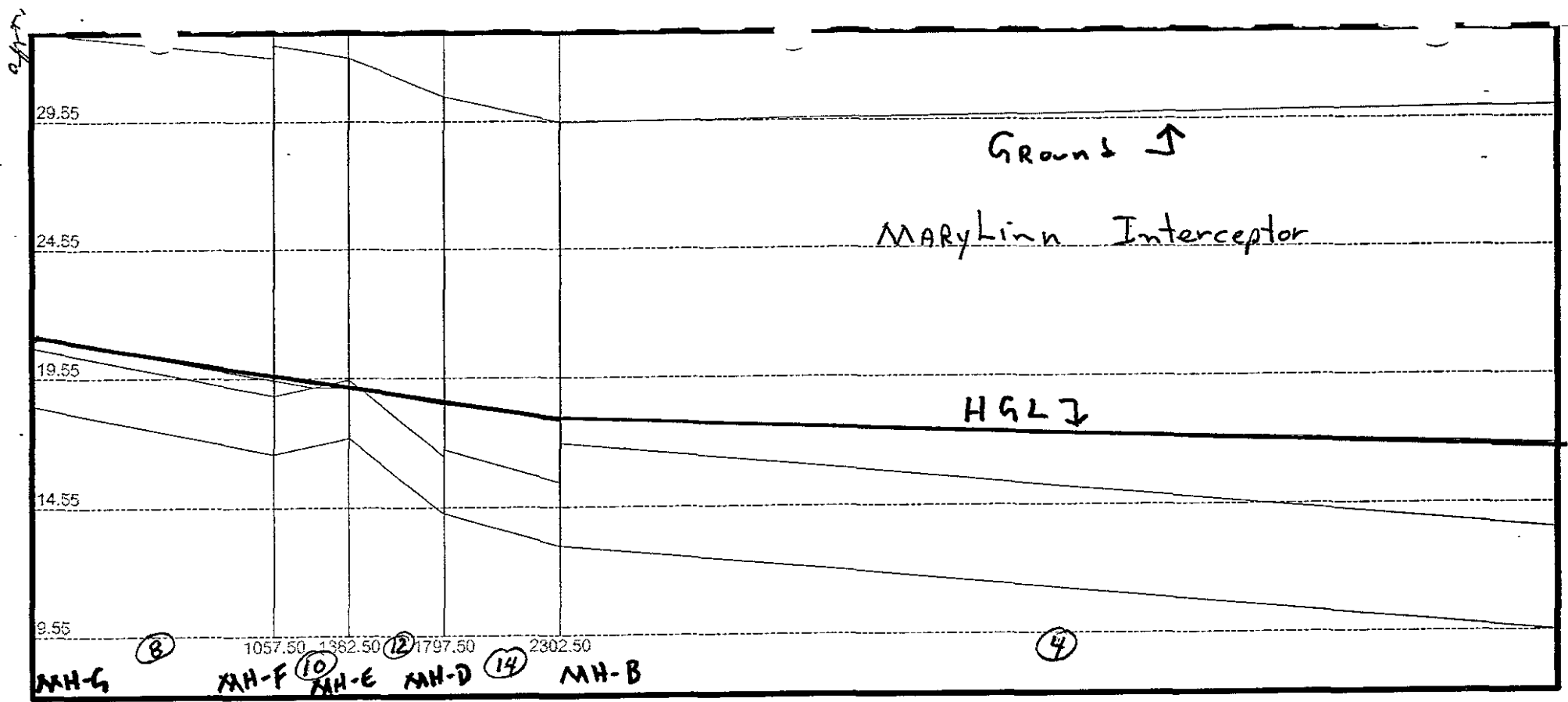
Q = 40 MGD



MH-C

Project: C:\Program Files\Pizer\HYDRA\JOBS\Milpitas P.S\Milpitas P.S. with grinder Final adjusted flow 040202 04/08/02.
Run: (4/8/2002 4:31:42 PM)

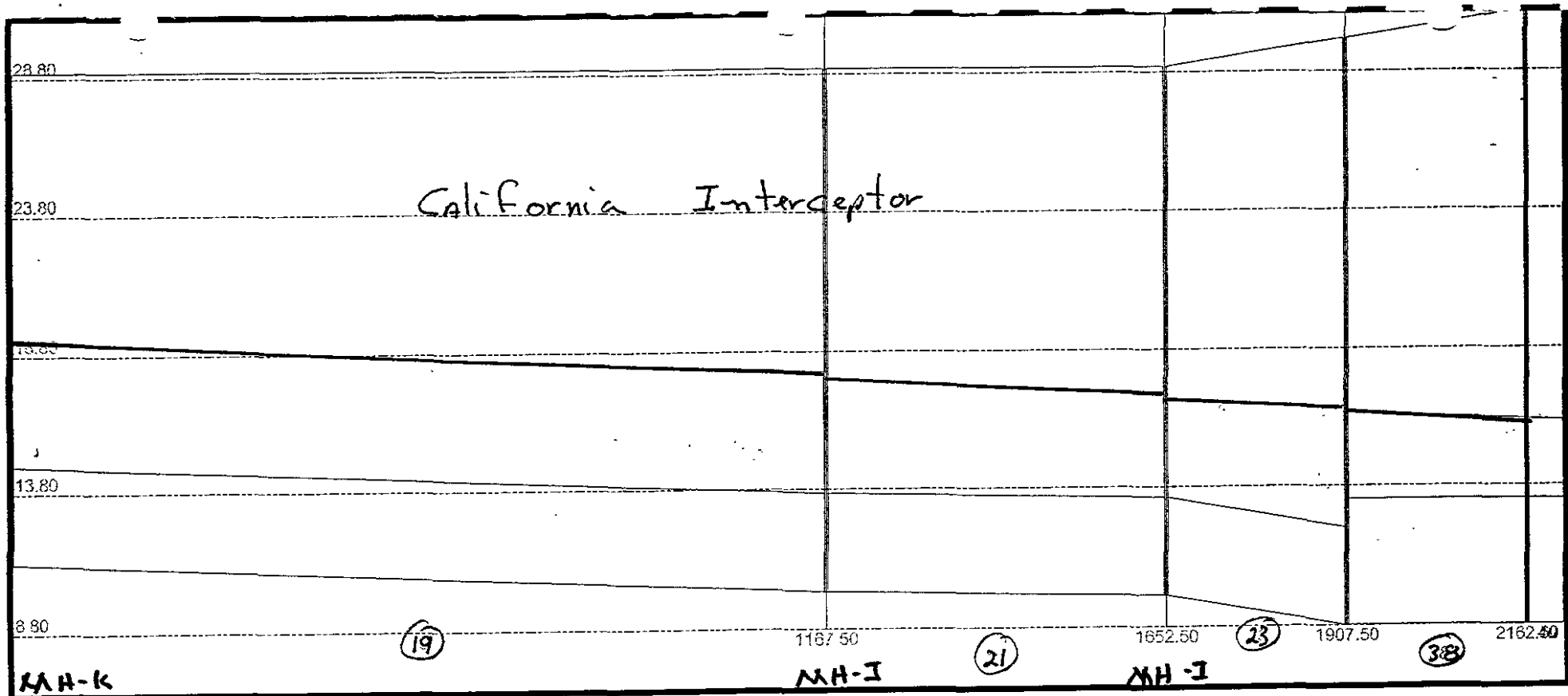
Name	Type	Length	Size	Inv. Up	Inv. Dn	HGL Up	HGL Dn	Gr. Up	Gr. Dn
1	EPI	993.00	36.00	14.94	13.01	18.32	18.07	29.00	29.50
4	EPI	4316.00	48.00	13.01	9.55	17.99	16.86	29.50	30.00
15	EPI	35.00	48.00	9.55	8.81	16.69	16.69	30.00	30.00
38	EPI	250.00	54.00	8.81	8.82	16.46	16.21	30.00	31.00
40	EPI	50.00	54.00	8.82	8.80	16.19	16.14	31.00	31.00
45	EPI	1.00	54.00	8.80	8.80	16.14	15.12	31.00	31.00



Project: C:\Program Files\Pizer\HYDRA\JOBS\Milpitas P.S\Milpitas P.S. with grinder Final adjusted flow 040202\

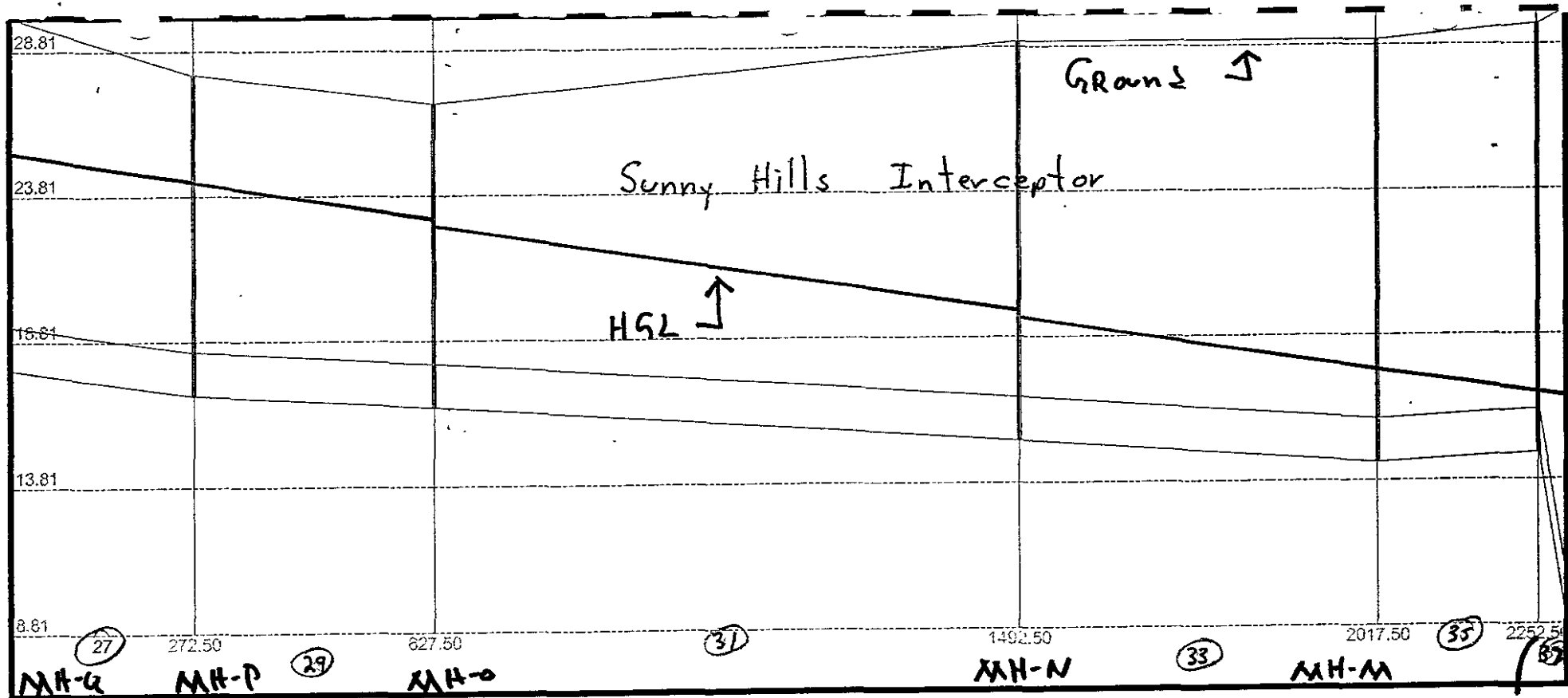
Run: (4/8/2002 4:31:42 PM)

Name	Type	Length	Size	Inv. Up	Inv. Dn	HGL Up	HGL Dn	Gr. Up	Gr. Dn
8	EPI	1050.00	27.00	18.49	16.63	21.20	19.48	33.00	32.00
10	EPI	320.00	27.00	16.63	17.23	19.48	19.20	32.50	32.00
12	EPI	410.00	27.00	17.23	14.30	19.20	18.53	32.00	30.50
14	EPI	500.00	30.00	14.30	13.01	18.53	18.07	30.50	29.50
4	EPI	4316.00	48.00	13.01	9.55	17.99	16.86	29.50	30.00



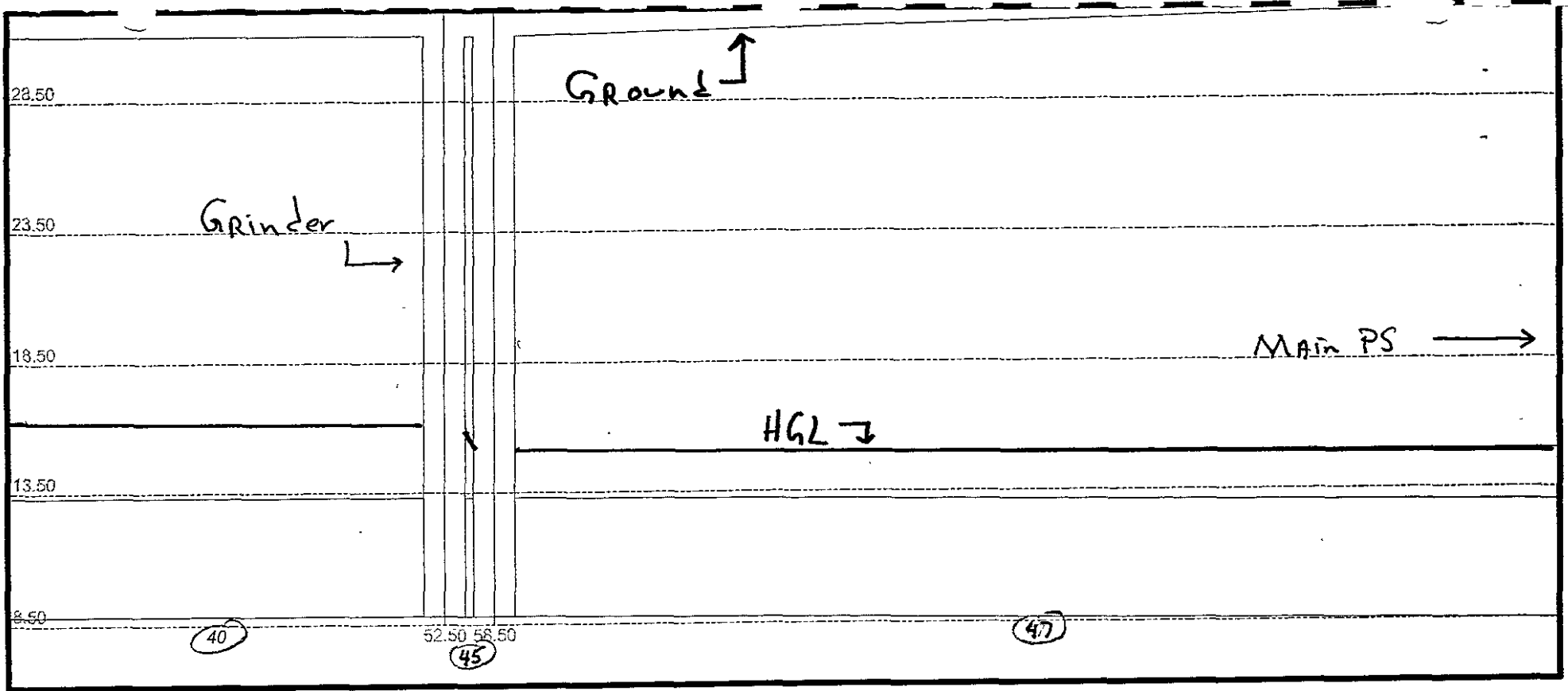
Project: C:\Program Files\Pizer\HYDRA\JOBS\Milpitas P.S\Milpitas P.S. with grinder Final adjusted flow 040202\
 Run: (4/8/2002 4:31:42 PM)

Name	Type	Length	Size	Inv. Up	Inv. Dn	HGL Up	HGL Dn	Gr. Up	Gr. Dn
19	EPI	1160.00	42.00	11.30	10.15	19.28	18.07	29.00	29.00
21	EPI	480.00	42.00	10.15	9.92	17.76	17.26	29.00	29.00
23	EPI	250.00	42.00	9.92	8.81	16.95	16.69	29.00	30.00
38	EPI	250.00	54.00	8.81	8.82	16.46	16.21	30.00	31.00
40	EPI	50.00	54.00	8.82	8.80	16.19	16.14	31.00	31.00



Project: C:\Program Files\Pizer\HYDRA\JOBS\Milpitas P.S\Milpitas P.S. with grinder Final adjusted flow 040202\
Run: (4/8/2002 4:31:42 PM)

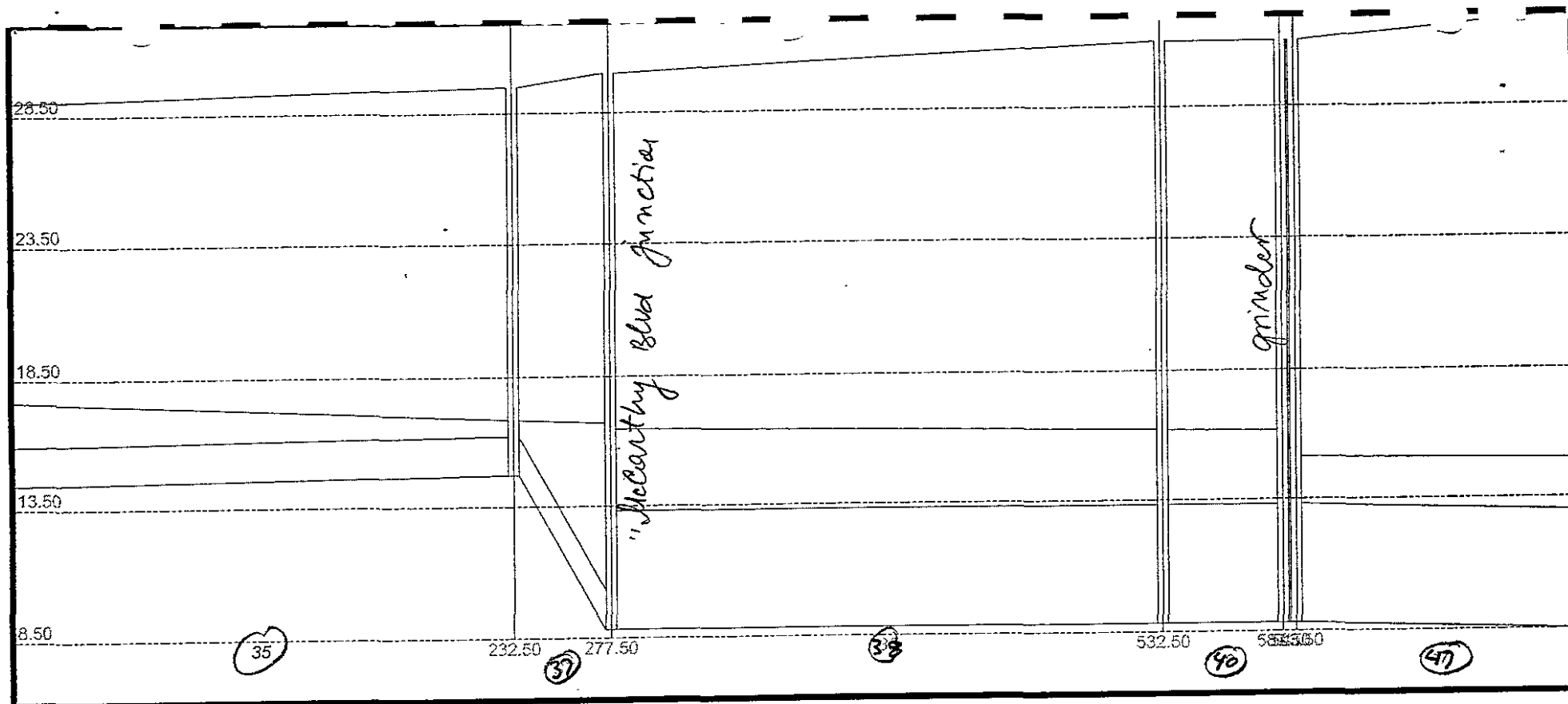
Name	Type	Length	Size	Inv. Up	Inv. Dn	HGL Up	HGL Dn	Gr. Up	Gr. Dn
27	EPI	270.00	18.00	17.84	16.94	25.31	24.37	30.00	28.00
29	EPI	350.00	18.00	16.94	16.51	24.29	23.08	28.00	27.00
31	EPI	860.00	18.00	16.51	15.23	22.75	19.77	27.00	29.00
33	EPI	520.00	18.00	15.23	14.41	19.44	17.64	29.00	29.00
35	EPI	230.00	18.00	14.41	14.70	17.64	16.84	29.00	29.50
37	EPI	40.00	18.00	14.70	8.81	16.82	16.69	29.50	30.00



Project: C:\Program Files\Pizer\HYDRA_JOBS\Milpitas P.S\Milpitas P.S. with grinder Final adjusted flow 040202\

Run: (4/8/2002 4:31:42 PM)

Name	Type	Length	Size	Inv. Up	Inv. Dn	HGL Up	HGL Dn	Gr. Up	Gr. Dn	
40	EPI	50.00	54.00	8.82	8.80	16.19	16.14	31.00	31.00	
45	EPI	1.00	54.00	8.80	8.80	16.14	15.12	31.00	31.00	→ grinder
47	EPI	125.00	54.00	8.80	8.50	15.12	15.00	31.00	32.00	



Project: C:\Program Files\Pizer\HYDRA\JOBS\Milpitas P.S\Milpitas P.S. with grinder Final adjusted flow 040202\
 Run: (4/8/2002 4:31:42 PM)

Name	Type	Length	Size	Inv. Up	Inv. Dn	HGL Up	HGL Dn	Gr. Up	Gr. Dn
35	EPI	230.00	18.00	14.41	14.70	17.64	16.84	29.00	29.50
37	EPI	40.00	18.00	14.70	8.81	16.82	16.69	29.50	30.00
38	EPI	250.00	54.00	8.81	8.82	16.46	16.21	30.00	31.00
40	EPI	50.00	54.00	8.82	8.80	16.19	16.14	31.00	31.00
45	EPI	1.00	54.00	8.80	8.80	16.14	15.12	31.00	31.00
47	EPI	125.00	54.00	8.80	8.50	15.12	15.00	31.00	32.00

4/9/2002 9:51:01 AM

Run 4A

Existing Pipes - Sorted by User's ID

UserID SEQ	G_ID	Length	Ground Up/Dn	Invert Up/Dn	Slope	Diam	"n"	DesignQ	DesVel	d/D	Qfull Qmax Qexcess	NewDiam ParDiam	HGL Up/Dn	Surcharge
1		993.00	29.00	14.94	0.0019	36	0.013	10.676	3.78	0.42	29.481	0	18.32	Yes
2	1		29.50	13.01							27.255	0	18.07	
											16.579			
10		320.00	32.50	16.63	-0.0019	27	0.013	12.532	0.20	0.00	0.000	0	19.48	Yes
6	10		32.00	17.23							0.000	0	19.20	
											0.000			
12		410.00	32.00	17.23	0.0071	27	0.013	12.532	6.50	0.49	26.247	0	19.20	Yes
8	12		30.50	14.30							24.265	0	18.53	
											11.733			
14		500.00	30.50	14.30	0.0026	30	0.013	12.532	4.47	0.56	20.887	0	18.53	Yes
10	14		29.50	13.01							19.310	0	18.07	
											6.778			
15		35.00	30.00	9.55	0.0211	48	0.013	23.208	10.99	0.26	209.428	0	16.69	Yes
14	15		30.00	8.81							193.616	0	16.69	
											170.408			
19		1,160.00	29.00	11.30	0.0010	42	0.013	32.491	3.38	1.00	31.762	45	19.28	Yes
16	19		29.00	10.15							29.364	21	18.07	
											-3.127			
21		480.00	29.00	10.15	0.0005	42	0.013	32.491	3.38	1.00	22.082	54	17.76	Yes
18	21		29.00	9.92							20.414	36	17.26	
											-12.077			
23		250.00	29.00	9.92	0.0044	42	0.013	32.491	6.91	0.49	67.217	0	16.95	Yes
20	23		30.00	8.81							62.142	0	16.69	
											29.651			
27		270.00	30.00	17.84	0.0033	18	0.013	6.189	3.50	1.00	6.079	21	25.31	Yes
22	27		28.00	16.94							5.620	8	24.37	
											-0.569			
29		350.00	28.00	16.94	0.0012	18	0.013	6.189	3.50	1.00	3.691	24	24.29	Yes
24	29		27.00	16.51							3.412	18	23.08	
											-2.777			
31		860.00	27.00	16.51	0.0015	18	0.013	6.189	3.50	1.00	4.062	24	22.75	Yes
26	31		29.00	15.23							3.755	18	19.77	
											-2.434			
33		520.00	29.00	15.23	0.0016	18	0.013	6.189	3.50	1.00	4.181	24	19.44	Yes
28	33		29.00	14.41							3.866	15	17.64	
											-2.323			

Run 4A

Existing Pipes - Sorted by User's ID

UserID SEQ	G_ID	Length	Ground Up/Dn	Invert Up/Dn	Slope	Diam	"n"	DesignQ	DesVel	d/D	Qfull Qmax Qexcess	NewDiam ParDiam	HGL Up/Dn	Surcharge
35		230.00	29.00	14.41	-0.0013	18	0.013	6.189	0.20	0.00	0.000	0	17.64	Yes
30	35		29.50	14.70							0.000	0	16.84	
											0.000			
37		40.00	29.50	14.70	0.1472	18	0.013	6.189	16.14	0.29	40.404	0	16.82	Yes
32	37		30.00	8.81							37.353	0	16.69	
											31.164			
38		250.00	30.00	8.81	0.0000	54	0.013	61.888	0.20	0.00	0.000	0	16.46	Yes
34	38		31.00	8.82							0.000	0	16.21	
											0.000			
4		4,316.00	29.50	13.01	0.0008	48	0.013	23.208	3.36	0.54	40.780	0	17.99	Yes
12	4		30.00	9.55							37.701	0	16.86	
											14.493			
40		50.00	31.00	8.82	0.0004	54	0.013	61.888	3.89	1.00	39.437	66	16.19	Yes
36	40		31.00	8.80							36.460	48	16.14	
											-25.428			
45		1.00	31.00	8.80	0.0000	54	0.417	61.888	0.20	0.00	0.000	0	16.14	Yes
38	45		31.00	8.80							0.000	0	15.12	
											0.000			
47		125.00	31.00	8.80	0.0024	54	0.013	61.888	6.50	0.58	96.601	0	15.12	Yes
40	47		32.00	8.50							89.308	0	15.00	
											27.420			
8		1,050.00	33.00	18.49	0.0018	27	0.013	12.532	3.79	0.77	13.067	30	21.20	Yes
4	8		32.00	16.63							12.081	8	19.48	
											-0.451			

Appendix E

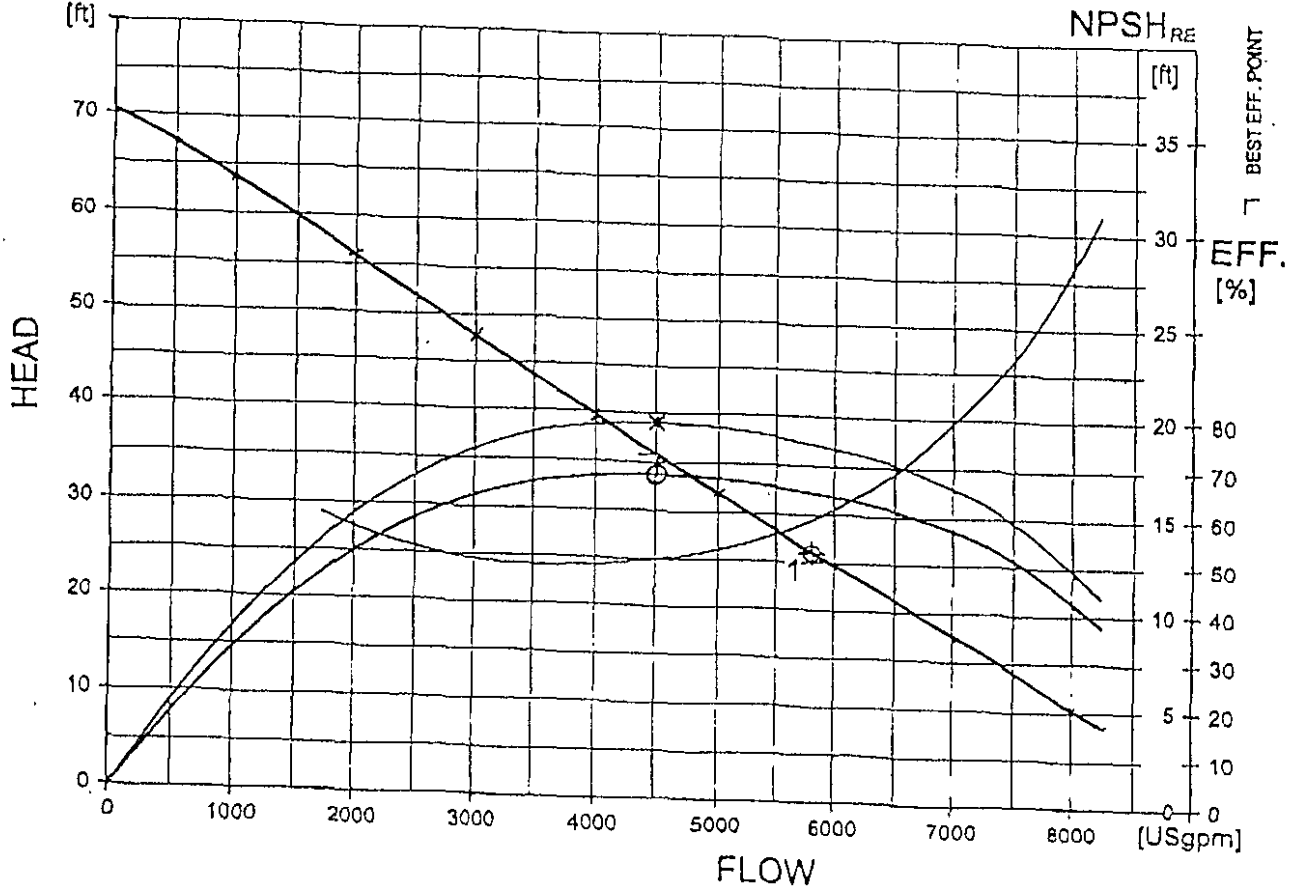
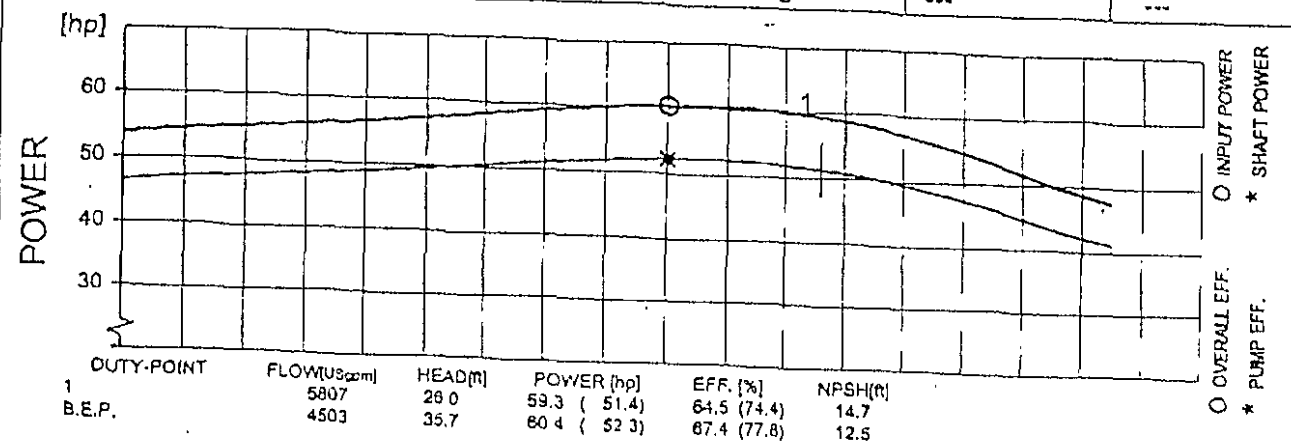
Pump Curves

Proposed Submersible Pump Station

Small Pump

1013

FLYGT		PERFORMANCE CURVE				PRODUCT CP3300.181		TYPE LT	
DATE 2002-05-09		PROJECT				CURVE NO 63-805-00-8010		ISSUE 2	
POWER FACTOR 0.82		1/1-LOAD 88.0 %		3/4-LOAD 88.5 %		1/2-LOAD 85.0 %		RATED POWER ... 60 hp	
EFFICIENCY 88.0 %		---		---		---		STARTING CURRENT ... 360 A	
MOTOR DATA		---		---		---		RATED CURRENT ... 80 A	
COMMENTS		---		---		---		IMPELLER DIAMETER 420 mm	
		INLET/OUTLET - /300 mm		RATED SPEED ... 875 rpm		TOT. MOM. OF INERTIA ... 2.3 kgm2		NO. OF BLADES 3	
		IMP. THROUGHLET 102 mm				MOTOR # 35-28-8AA		STATOR 38D	
						FREQ. 60 Hz		PHASES 3	
						VOLTAGE 460 V		POLES 8	
						GEARTYPE ---		RATIO ---	



FLYPS2.11 (20010918)

Performance with clear water and ambient temp 40 °C

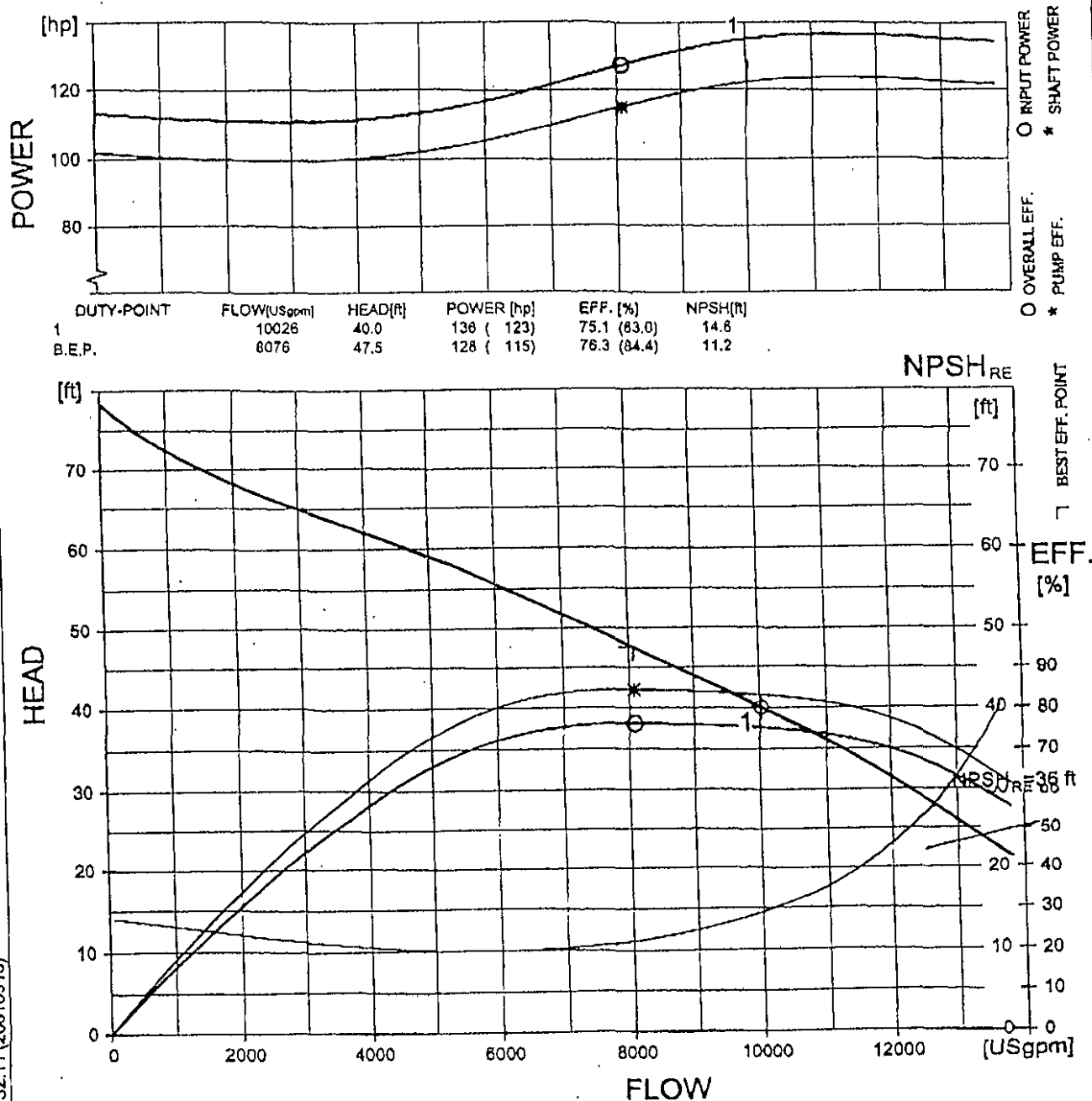


CURVE

Large Pump

1043

FLYGT		PERFORMANCE CURVE				PRODUCT CP 3400/735		TYPE	
DATE 2002-05-09		PROJECT				CURVE NO C3400-63-1030		ISSUE 5	
POWER FACTOR 0.88		1/1-LOAD 0.59		3/4-LOAD 0.48		1/2-LOAD 0.48		RATED POWER 135 hp	
EFFICIENCY 90.5 %		90.0 %		87.5 %		STARTING CURRENT ... 960 A		IMPELLER DIAMETER 515 mm	
MOTOR DATA		---		---		RATED CURRENT ... 211 A		MOTOR # 43-44-10FA	
COMMENTS		INLET/OUTLET - /400 mm		RATED SPEED 710 rpm		TOT MOM.OF INERTIA ... 7.2 kgm2		STATOR 01D	
		IMP. THROUGHLET 110 mm		NO. OF BLADES 3		FREQ. 60 Hz		PHASES 3	
						VOLTAGE 460 V		POLES 10	
						GEARTYPE ---		RATIO ---	



FLYPS2.11 (20010918)

FLYGT

CURVE

Performance with clear water and ambient temp 40 °C